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WORLD OIL

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a quick look at WORLD OIL this month

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first.

CURRENT OUTLOOK

☐ **Do your college interview methods meet the test?** Is your interviewing program up-to-date compared with other companies? This is the time of year when the annual "student rush" is on. Competition to fill industry positions with top calibre college graduates is getting keener. The job of hiring college graduates has become big business. And with the need and supply at such odds, no crystal ball is needed to see the why of this stampede to college campuses. But there are problems involved. In an attempt to clarify these problems and offer some possible solutions, WORLD OIL surveyed 45 colleges and 35 oil companies on the subject. The intent is to provide information and ideas that will help both the industry interviewer and the college placement director. Read . . . Employing the College Graduate ..... Page 90

45 colleges report that oil company recruiters have multiplied nearly 7 times in 10 years.

Turn the Page ▶

THIS MONTH . . .

☐ **Limited budgets demand** careful attention by the small operator to the matter of geological assistance. Should he employ a full-time geologist or rely on a consultant. Should he concentrate exploration activities in one or two areas or spread his efforts. For an easy-to-read, helpful discussion of these problems, turn to **Page 88. How the Small Operator Survives**. . . **Daniel A. Busch**

☐ **U. S. and Canadian reserves** of oil and natural gas were increased to new highs in 1955. Operators proved up more new reserves than were used up. This was done in spite of record breaking consumption and production. The results were favorable. But they pointed up the fact that oil and gas are becoming harder and more costly to find. The net addition to reserves of crude in the U. S. was smallest for any year since World War II. Read **The Changing Panorama . . . Page 100**

DRILLING ARTICLES

☐ **Crooked Holes Can Be Controlled** by use of proper bottom-hole assemblies, proper drilling practices, and the application of the Woods-Lubinski data. Additional proof of this is provided in another survey by the Southwestern API Study Committee on Straight Holes. For results of this survey on crooked hole conditions in the Headlee-Warsan Trend of Ector and Midland counties of West Texas, turn to **Page 183. Controlling Crooked Holes** . . . . . **H. M. Rollins**

☐ **Unnecessary Waste of Drilling Fluid** due to the accumulation of drilled solids is being eliminated by the use of a three-inch ID cyclone. By removing drilled solids from unweighted muds and recovering barites from high-density systems, you'll need less mud and save money. Turn to **Page 190** for complete details on the equipment and tests made with it. **Three-Inch ID Cyclone Removes Solids from Drilling Fluid**. . . . . **W. E. Bergman, C. J. Engle, S. J. Marwil and M. R. Tek.**

☐ **A Contractor Can Save Money** by proper installation, frequent checking, and proper maintenance of power chains. Beginning on **Page 197** is a review of chain lubrication practices and a check list for installation and alignment of chain drives. **Don't Neglect Your Power Chains**. . . . . **David Breith**

☐ **Valuable Subsurface Information** can be obtained without interrupting the drilling operation by collecting formation cuttings on three different mesh screens. This new method is fast, simple and inexpensive. It provides a fair substitute when electric logs cannot be run. For more information on this new development, turn to **Page 206. Sieve Residue Logs.** **W. L. Buning**

Exploration

☐ **A glance at the future** shows that 25 years from today the U. S. probably will require twice as much oil per year as it does now. It cannot depend on large supplies known to exist outside the country. The needed oil must be found within the U. S., or certainly within the North American continent. It can be discovered. Many areas have had very little drilling yet have good possibilities of yielding many large fields. New techniques are being used. They are helping to maintain high discovery rates. There is no serious threat of a shortage of petroleum in the U.S. in the foreseeable future. Turn to **Page 80. Better Exploration Promises Enough American Oil for U. S.** . . . . . **A. I. Levorsen**

☐ **Take a look at Mississippi.** The Ansley field of Hancock County, Mississippi, is perhaps one of the most valuable of recent commercial production finds. Furthermore, it is suspected that deeper pays beneath this field communicate with the Citronelle field more than 100 miles away. For the story, maps and structure of this area, turn to **Page 115. Mississippi Structure Shows Promise of Vast Reserves**. . . . . **J. Willis Hughes**

☐ **The salt dome north flank theory,** which proposes the north flank to be a better drilling prospect than the south flank, gains little support when history is reviewed. Experience in South Louisiana salt dome operations shows the odds for drilling a producing well to be much the same regardless of the flank selected. This statistical study on **Page 158** was based on 7175 wells drilled on 73 salt domes. **Is a Salt Dome's North Flank Its Best Prospect?** . . . . . **W. C. Shead and Edwin A. Allen**

☐ **Trouble Sometimes Appears** where least expected. A mud hose is perhaps one of the sturdiest and least noticed pieces of equipment on a rig. But it can give trouble if abused. For some hints on construction and proper care of the mud suction hose, see **Page 210. How to Get the Most from Mud Pump Hose.** **Richard C. Stoner**

☐ **A Good Safety Program** is one that elicits full participation from all employes . . . from the "weevil" roughneck to top management. For some in-

WORLD OIL, published every month except semi-monthly in February and August. Entered as THE OIL WEEKLY as second class mail matter December 23, 1916, at postoffice at Houston, Texas, under the act of March 3, 1879.

Looking Ahead . . .

. . . **The great business boom faltered in January and February.** But it began rolling again in March. It now shows many signs of going strong at least through 1956—and perhaps for several years. U. S. industry now plans to spend $35 billion on expansion of plants and facilities in 1956. That will be $6 billion or over 20% more than its record capital expenditures of 1955. The two recently faltering major industries, auto making and housing construction, are beginning to bud out again with spring. Optimism is in the air. Confidence prevails. The stock market recently climbed higher than ever before.

•

. . . **Steel mills continue to operate near full capacity.** Steel, aluminum, copper, and other metals remain scarce and threaten to become scarcer. Prices of nonfarm raw and manufactured goods have been creeping upward. Steel workers expect to get wage raises this summer. If they do, prices of steel and steel products will be further increased. Prices of steel goods previously were raised rather sharply as recently as last summer. (WORLD OIL, August 1, 1955, Page 44.) Steel workers got a wage increase of 15 cents an hour July 1, 1955. Basic steel immediately was raised $7.50 a ton or 5.8%, and alloy and special steels 10% to 12%. Pipe prices then were raised by $11 to $18 per ton.

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. . . **In view of the recent upturn in business, the oil industry now has a quite favorable outlook.** In fact, good prospects for this industry contribute materially toward the rosy general picture. At the beginning of the year it was generally expected that oil use would increase 4 or 5 percent in 1956 over 1955. It now seems that estimate will be fulfilled certainly and may be exceeded. The industry will do a new record volume of business this year. In doing so, it will have to produce and refine more oil than ever before. With demand for crude strong, operators will need to do a record amount of drilling.

•

. . . **Increased volumes of business will favorably affect 1956 earnings** of oil companies and operators. The greater volumes heretofore have promised to boost profits moderately above 1955. Increases in sales of crude and products have been partially offset by increases in costs of materials last summer and fall and wage increases in the oil industry last year and this year. The industry is paying substantially more for materials and wages now than a year ago. But larger volumes of business help to cover the extra costs.

. . . **For future months and especially the latter half of the year the outlook for oil industry earning power is clouded.** Oil companies granted raises of 6 percent or 15 cents an hour in salaries and wages February 1 to non-union employes. The same increase was offered to union workers, who will get raises of that amount or more. Now oil companies face the threat of new increases in costs of steel and other materials. Increases in steel industry wages and prices are indicated around the middle of the year. Higher costs of pipe and other materials after midyear, in addition to higher payrolls, would eat into margins of profit. Higher prices for petroleum products and crude oil are already being urged within the industry. To bolster earning power and keep the industry healthy, the increases may be urgently needed after the middle of the year.

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. . . **Recent events have enhanced the prospects of a general crude raise and advances in product prices.** Higher prices henceforth will be more definitely needed to cover higher costs and draw forth larger oil supplies to meet greater demand. Strong demand has forced prices higher in other industries and will exert upward pressure on oil prices. Producers are experiencing increases in costs of finding and producing oil. Yet crude prices have not increased materially since they were raised 25 cents a barrel June 15, 1953, nearly three years ago.

•

. . . **Officials of several major companies lately have expressed doubt that crude prices would be increased this year** because of surplus U. S. and world producing ability and competition of imported oils. Others in the industry contend that higher crude postings are becoming imperative because of much higher costs. "If crude oil prices do not increase soon," said L. F. McCollum, president of Continental Oil Company, "capital investments in exploratory activities will be discouraged, and we will move inevitably into a period of shortages." He said crude producers are now liquidating their reserves at prices based on finding costs of earlier years, not today's replacement costs. Crude prices must be advanced, he said, to cover producers' rising costs. The pressure for a general crude price increase in 1956 is building up. Higher steel prices at midyear might make a general crude raise certain.

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Actions Speak Louder than Publicity

Public opinion of the petroleum industry in the U. S. has received a drastic setback as a result of the natural gas bill fiasco and the subsequent Senate investigation of political financial contributions.

The oil industry still has a long, long way to go before it can list the public as a friend. This is true although the Oil Industry Information Committee has done yeoman service since its beginning 10 years ago, and oil companies have increased their own public relations efforts many fold during the same period.

Last year alone, 30,000 OIIC volunteers from the industry told the story of oil to nearly 10 million people through motion pictures. Several million pieces of educational material were distributed to 7320 schools. Personal contacts were made with 67 percent of the nation's newspapers, radio and television stations.

Nevertheless, a recent public opinion survey showed:

- 23 percent of the American public thinks the oil industry makes too much profit.
- 12 percent of the people questioned favored government regulation of the oil industry.
- A sizeable number thought the industry not fully competitive, is controlled by a few companies, and charges prices that are too high.

The truth is that too large a share of the U. S. public does not look with favor on the industry. It is important to note that the survey was made before the natural gas bill debacle. Only the future will tell how much damage this action did to the industry's public relations standing.

Various reasons are given for the industry's lack of progress in winning public favor. For one thing, too many oil men believe that public relations means publicity relations. If this were true, the OIIC program would have solved the public attitude problem long ago. Others think it is a general distrust of big business.

The problem goes much deeper. It is patent that the OIIC and company public relations departments cannot shoulder the full responsibility alone. They must be aided by proper actions and good judgment by top management of the industry.

Most important of all, the industry must first deserve the good things that are said about it. Before this can be accomplished, oil men must start evaluating their actions in terms of public attitude rather than in column inches or total hours on radio and television.

Unwise actions are giving the industry entirely too much bad publicity. This offsets the good created by favorable publicity. No better example could be cited than the recent natural gas bill. During the heat of the debate some of the nation's most influential newspapers took up the cudgel against wealthy oil interests "buying" their way free of government control. No mention was made of the money spent by the opposition.

Numerous other unfavorable stories about oil appear in the press all too frequently. Before real progress can be made, the industry must stop its internal bickering. This business of throwing rocks at other segments of the industry is certain to impede public relations progress.

Shell President H. M. S. Burns has declared that internal bickering "keeps things stirred up in a sea of ferment and makes our great industry look like an aggregation of brawling school kids who deserve to be slapped down and regimented by Uncle Sam."

The oil industry must seek to settle its differences within industry circles rather than before the public. Otherwise, adverse public opinion results.

First of all the industry must act in a fashion that merits the understanding and good will of the public. Then, good public relations will come naturally, because it will be deserved. Efforts of the OIIC and the public relations departments will then have a chance to do some real good.

American public opinion is formed from what the oil industry does—not from what it says. Actions speak louder than publicity.

PROBLEM . . .

To assure survival as a nation, the U. S. must not depend on imports. It must continue to find enough oil for its needs within the country and certainly within North America.

To find the required oil will be a tremendous job. The country's requirements will double within 25 years.

CAN IT BE SOLVED?

The required supplies can be developed, even though they will be twice as great by 1980 as they are now.

SOLUTION . . .

Many areas have had very little drilling, yet have good possibilities of containing numerous large fields.

Geologists and geophysicists are using new ideas and techniques that will help to make discoveries.

Efforts are being made to increase the percentage of recovery of the oil present in the formations. Better methods will add greatly to recoverable reserves.

Vast amounts of oil can be made available by development of economic methods of extracting it from shale and tar sands.

Better Exploration Promises

New ideas and improved techniques for searching out oil offset any alarm over alleged petroleum shortage.

By A. I. LEVORSEN
Consulting Geologist, Tulsa

THE U. S. WILL require twice as much oil per year by 1980 as it does now. It will then need around 14 to 15 million barrels of oil daily, or the equivalent of an East Texas pool every year. This is indicated by recent and current trends of petroleum consumption.

At present there is probably enough oil outside the U. S. to run the world, including the U. S., for a long time. But to import our oil needs is to risk our future as a nation. We must discover, in ever increasing amounts, a continuing supply of oil. We must find it, preferably within the U. S., but certainly within North America, if we are to survive under present world tensions.

The required oil can be discovered. There is no cause to be alarmed over any expected shortage of petroleum in the U. S. in the foreseeable future.

There are many areas which should yield numerous important new oil and gas fields when adequately drilled. Geologists and geophysicists are developing new ideas and techniques for searching out oil deposits. Ways are being found to increase the percent-

U. S. Oil Needs Can Be Met Through 6 Things That Geologists Are Talking About . . .

1. Structural Traps . . .
Better data for locating structural traps. While structures are getting harder to find, new techniques in both geology and geophysics will aid in discovering many new ones.

2. Stratigraphic Traps . . .
Better data for locating stratigraphic traps. Three-fourths of the oil ultimately found in the U. S. will be in stratigraphic traps. Better methods of exploring for them are being worked out.

3. Geology of Fluids . . .
Revolutionary ideas for finding new fields have been developed through studies of the flow of gas, oil, and water in the reservoirs. These studies indicate, for example, possible fields on flanks of anticlines instead of the tops. Many anticlines heretofore barren on top will yet produce oil.

4. Geologic History . . .
Better understanding of the geologic history of an area greatly helps in evaluating its oil and gas possibilities. The best hunting grounds are spotlighted.

5. Geologic Manpower . . .
One of the best ways the oil industry can speed up discoveries is to get more and better minds working in exploration. It can do this by helping to staff the schools with good professors.

6. Complete Oil Recovery . . .
Of 270 billion barrels of oil discovered in the U.S., only 88 billion or 32% will be recoverable by all known primary and secondary methods. The industry must do a better job of recovery on the remaining 182 million barrels. Recovering 50% or even 10% of this oil currently left in the ground would provide vast amounts.

age of recovery of the oil in the reservoirs. Conservation is being practiced. Means are being sought for extracting oil from shale and tar sands.

There are as many and as good new ideas and techniques in sight and coming over the horizon now as ever before. There is no more reason to say we are running out of oil now than there was 10, 20, or 30 years ago. There would be danger only if we were to run out of ideas—or incentive, techniques, and trained men for finding the needed oil.

The finding of oil in the U. S. has become increasingly difficult. Exploration requires advanced methods and techniques. Discoveries are made through the coordinated efforts of geological specialists.

Toward the end of increasing their effectiveness, geologists currently are trying to broaden their understanding of basic geology. They are trying also to develop better techniques.

The principle of oil and gas exploration is quite simple. It can all be stated in six words. "Find a trap—then drill it." The best place to drill is on an anticline or near an up-dip sand pinch-out. As long as the evidence is clear and evident, there is no particular problem. But as the years roll on, the clear and evident structures are drilled. In each area it eventually requires the combined efforts of many people, each expert in his particular field, to locate the traps. The principle of exploration remains the same. But the application becomes extremely complex—so complex in fact that when traps cannot be found, wells are drilled anyway.

Petroleum geologists have become highly specialized. Their work generally breaks down into two broad categories: (1) the gathering of data by specialists, who are expert technicians, and (2) the integrating of data by idea men into geologic prospects worth drilling. The gathering of data includes such work as surface structural mapping, measuring geologic sections, subsurface mapping, examination of well cuttings, well sitting, electric and radioactive log interpretations, and seismic and other geophysical surveys designed to locate favorable structures.

Where the data collected show a

Enough American Oil for U. S.

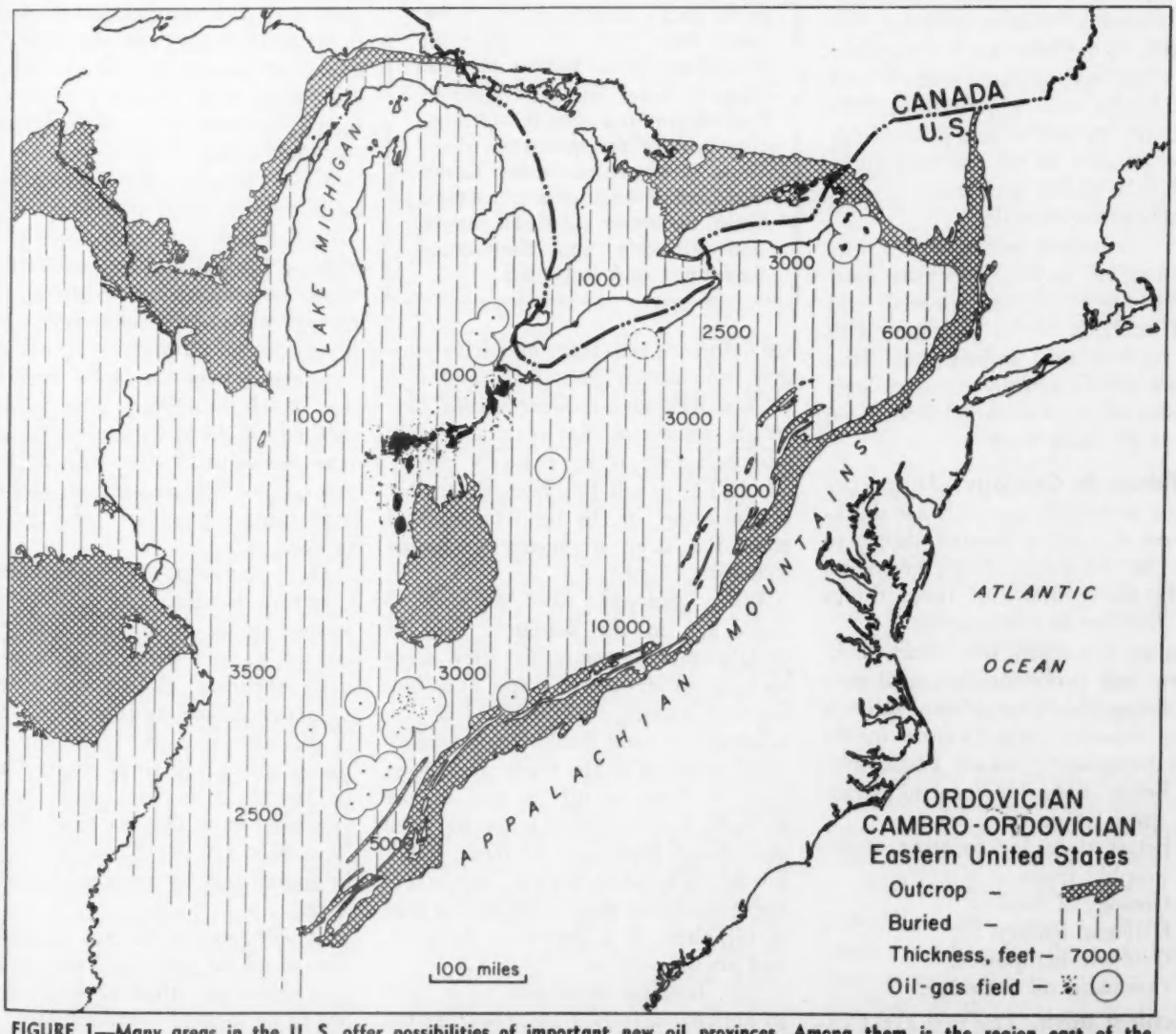


FIGURE 1—Many areas in the U. S. offer possibilities of important new oil provinces. Among them is the region east of the Mississippi River. The Ordovician and Cambro-Ordovician formations heretofore have yielded oil in some areas, shown in black. More drilling logically would uncover additional pools.

trap in the reservoir rock or a favorable reservoir condition, it is a simple matter for the specialized technician to recommend drilling.

Because of increased geological complexities, an integration of several kinds of data has become more often necessary. This requires a broader background of experience and much more creative and deductive ability. Such integrator geologists may be called "generators." They can take a variety of obscure and miscellaneous data. From it they can conceive or generate a logical drilling prospect. The chief geologist of a major company employing hundreds of geologists recently said he would be happy if he could be assured of one generator for every 20 technician geologists he employs. It takes that many people, he said, to supply the geological technical data for one integrator—the data that can be thought through into prospects.

An oil operator should not necessarily expect a wellsite geologist, for example, to be able to put together surface geology, geologic history, and seismic data into a prospect. He should not expect a generator-geologist to be able to go out and know the details of the stratigraphy from his study of the samples.

There is no revolutionary new way of finding oil pools. Geologists must depend chiefly on the proved and tested methods of the past, but with modifications and refinements. The changes are in improved technology, extension of ideas already known, and most of all, hard work.

Big Things in Geology. Things petroleum geologists currently are thinking and discussing foretell things to come. In the years ahead, geologists will be doing many of these things that they are now discussing.

Among the many new ideas, techniques, and problems that geologists are talking about, six general subjects are of especial importance in the years immediately ahead. These are:

- Better data for locating structural traps.
- Better data for locating stratigraphic traps.
- Geology of fluids.
- Geologic history.
- Geologic manpower.
- Complete oil recovery.

Structural Data. The first great exploration idea that was developed in the search for petroleum was the anticlinal theory. This gradually expanded into the structural theory to take care of faulted and complex structural traps. In general, it means that oil and gas, being lighter than water and therefore responding to the forces of buoyancy, will collect in water-bearing reservoir rocks in traps that are concave upwards, either due to anticlinal folding, faulting, or combination of both.

The big advantage in the exploration of structural traps is that generally several potential reservoir rocks are deformed into traps on each structure, one above the other, and one wildcat well may explore several potential reservoirs. Structural traps, moreover, are often readily recognized. The result has been that most of the effort of the industry to find traps has been in trying to locate structural traps.

When geologists were working 30 years ago in the Seminole field of Oklahoma, for example, they were looking for structural traps, and they are still looking for them. Most any wildcatter would prefer a good structural prospect to any other. He knows that if there is oil or gas in the vicinity, a structure is a specific area that could hold one or more pools. In an oil-bearing region, any structural condition that could hold a pool of oil, then, is a first-class prospect, and always will be.

But, because structures have been so actively searched for, they are becoming more and more costly to find. The writer asked the same question of many geologists through the years. It is this: If you were assigned the job of finding 100 drillable prospects, what would be the average cost of each? The first few times the question was asked, along in 1936-1938, the answer was generally around $25,000 each.

Since then it has been going up. Now the average answer is on the order of $100,000 each. This includes all geological and geophysical work chargeable to finding a prospect. It does not include lease and drilling costs. Some even went as high as $200,000 to $300,000 per prospect over a period of several years. If half of this increased cost is inflation, the cost of finding a structural prospect now still is double the cost of 20 years ago. This probably reflects the increased geological difficulties of finding new prospects.

Historically, the search for structural traps in the U. S. has been to map the obvious ones first. They included those wells exposed at the surface, such as the "sheepherder" anticlines of the Rocky Mountains, or the Signal Hill type of fold of California, or some of the salt domes of the Gulf Coast.

Then followed the more obscure folds that required more careful and expert geologic mapping, then core drilling for the shallow hidden structures, then subsurface mapping where enough wells had been drilled to make a structural map, then geophysical mapping where no wells or only a few had been drilled. The dominant method of locating structural traps now and during the last 20 to 25 years is by seismic surveys, and most exploration money is spent for these surveys.

Our whole past experience in structure hunting has tended to be toward more refinement, more accuracy, greater detail, and to require more technical skills. And it seems to many geologists that this is what is still ahead of us. There are many more structural traps remaining to be found, it is true. But they are generally more obscure than those we have been finding. Most of them can be found only by greater attention to detail.

It will require, in fact, a combination of all the geological and geophysical techniques that we know if they are to be located commercially.

There seems to be now as in the past, moreover, enough new ideas and

Some of the Many Promising Areas for Oil Search in the U.S.

Large discoveries are possible in stratigraphic traps in California, the Rocky Mountains, the Appalachian basin, and around Gulf Coast salt domes. Some might equal East Texas or Pembina.

Hundreds of anticlines, especially in the Rocky Mountains, may have pools down their sides, although heretofore found barren on top.

Large reserves may be found in Ordovician and Cambro-Ordovician east of the Mississippi river. Those rocks are equivalent to the Mid-Continent's highly productive Viola limestone, Simpson sands, and Arbuckle and Ellenburger limestones and dolomites.

techniques to maintain a good discovery rate in spite of the number of structures that are being discovered and drilled each year. Because a structure is obscure or hidden below an unconformity or thrust fault does not mean that it is small. This has been shown by the experience in the Cuyama Valley of California and in the Ordovician of West Texas. We should also remember that structures are but one kind of trap in which oil occurs. The increased difficulty of finding structures does not necessarily mean an approaching shortage of oil.

Techniques and ideas that geologists believe will aid in finding more structures include microphoto-geology. As the name suggests, it is a microscopic examination of air photos to locate structure by microscopically analyzing obscure features. The surface structure is being remapped in many areas in a more detailed and careful manner. An example is the remapping of much of the Rocky Mountain region on 5 to 10 foot contour intervals. Correlations for subsurface mapping are improved by continuous velocity logging and use of pollen and spores found in well cuttings. Helping to find structures are new geophone patterns and the use of magnetic tape for recording seismic data. Magnetic tape permits much faster mapping. Derived data are in a much more usable form. The same tape can be used over and over again in the laboratory as new ideas of interpretation arise.

Stratigraphic Data. One of the great, early geological arguments in the petroleum industry was whether the oil in Pennsylvania and West Virginia was on anticlines or in sand patches and other irregularities in the sand distribution. Dr. I. C. White, possibly because he was a better salesman, won out with his statement of the anticlinal theory as the key to oil and gas occurrence. The writer believes it was E. DeGolyer who once said that if they had known the geological conditions surrounding the occurence of oil in those areas when the argument was raging, the anticlinal theory would never have evolved. The examples that were used to support the anticlinal theory were all later found to be sand occurrences. The folding was incidental or of minor importance. The pools actually were localized in sand patches that were on the flanks or crossed anticlines. The sand distribution was the critical feature—not the anticline.

We now call such traps "stratigraphic traps." They have been growing in relative importance with the years. As recently as last spring, Paul Lyons, president of the Society of Exploration Geophysicists, reported that:

"It is possible to predict . . . that perhaps 75 percent of the oil ultimately found in the U. S. will be stratigraphic."

A recent article by H. P. Woodward summarizes the situation in the Appalachian basin as follows:

"Up-dip pinch-outs of sands, stratigraphic traps, subsequent fracture porosity, and the wedging of reservoir and enclosing impermeable strata have been responsible for the largest number of important producing pools in the Appalachian Basin . . . strict adherence to the anticlinal theory of accumulation would be of little value in rediscovering these pools were they now unknown."

About the Author

DR. A. I. LEVORSEN, internationally known petroleum geologist, is a past president of Geological Society of America and of American Association of Petroleum Geologists. He is author of the book, Geology of Petroleum, published in 1954. Born in Fergus Falls, Minn., Levorsen holds the following degrees: University of Minnesota, Engineer of Mines, 1917; Colorado School of Mines, Doctor of Engineering (honorary); and University of Minnesota, Doctor of Science (honorary). Levorsen was a geologist with various oil companies until 1935; consulting geologist, 1931-1934, 1935-1945, and 1951 to now; professor of geology and dean of the School of Mineral Sciences, Stanford University, California, 1945-1951. He has had geological experience in several foreign countries, including Canada, Pakistan, Brazil, France, and North Africa.

If 75 percent of the oil is stratigraphic, we have been wasting a lot of effort. At least 75 percent or more of our effort has been in the search for structural traps.

The chief advantage of the structural trap is that several reservoir formations may form traps in one structure. The stratigraphic trap is a "single shot" prospect. It does have the advantage, however, of generally being an older trap than the structural trap. It therefore has had a longer time to accumulate a pool.

There are several general basic types of stratigraphic traps. All of them contain many important examples of oil pools. Some are shown in Figures 2, 3, 4, 5. One is the folded, up-dip pinch-out of a reservoir rock, such as occurs in the East Texas and East Coalinga pools. Another is the irregular, up-dip pinch-out of the reservoir rock on a uniform regional dip, of which the Pembina pool in Canada is the outstanding example. Others are the sand-patch pool, as the Dora and Burbank pools in Oklahoma; the shoestring sand pools, as in Kansas; and the limestone reef pools, as the Scurry pool in Texas. Most are characterized by little or no local folding, faulting, nor anything that can be determined from the surface. They just occur, often completely unexpectedly. Their discovery is one of the key problems of the geologists, geophysicists, and engineers.

If 75 prcent of our oil is to be in traps such as these, it is extremely important to have some logical method of exploring for them. Some of the ideas that geologists are talking about that will do a better job of finding stratigraphic pools include:

- Greater attention to detail, especially in the accuracy and recognition of not only the well samples, but also the fluid samples.
- Careful analysis of the orientation of sand grains in buried sand bars.
- Pattern drilling, that is, holes drilled on regular centers, such as one mile, for example, or even one-half mile centers, to test for pools at 1000 to 5000 feet in depth.
- More holes down the flanks and along the plunge of dry anticlines before they are finally condemned. A dry hole at the crest of an anticline or close to a salt dome does not rule out the flanks, where pinch-outs,

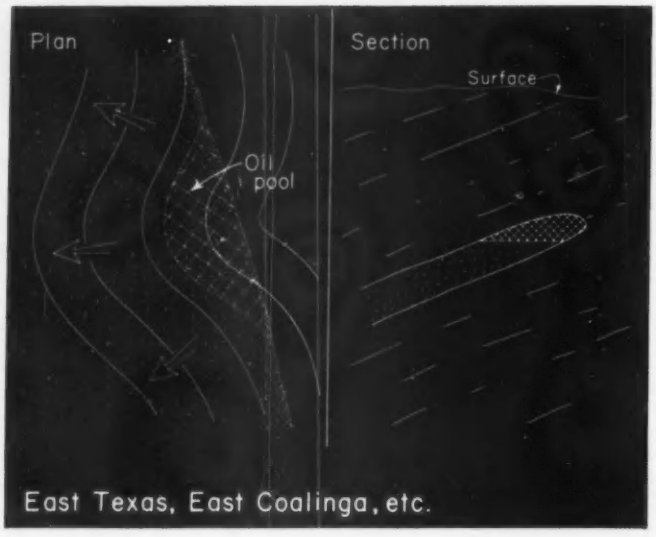


FIGURE 2

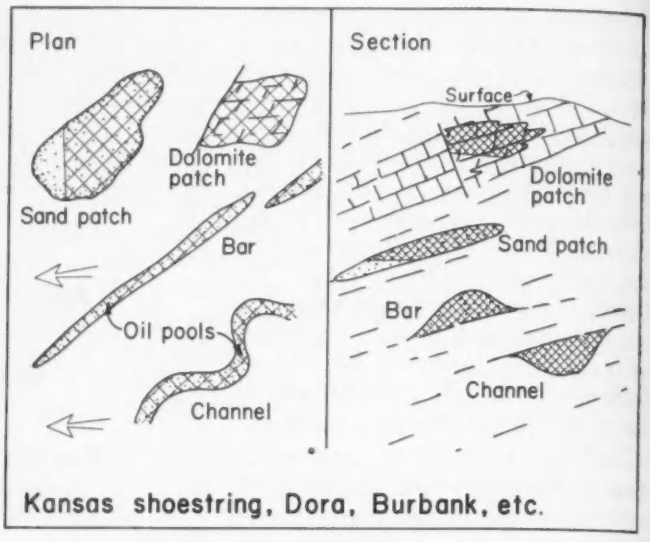


FIGURE 4

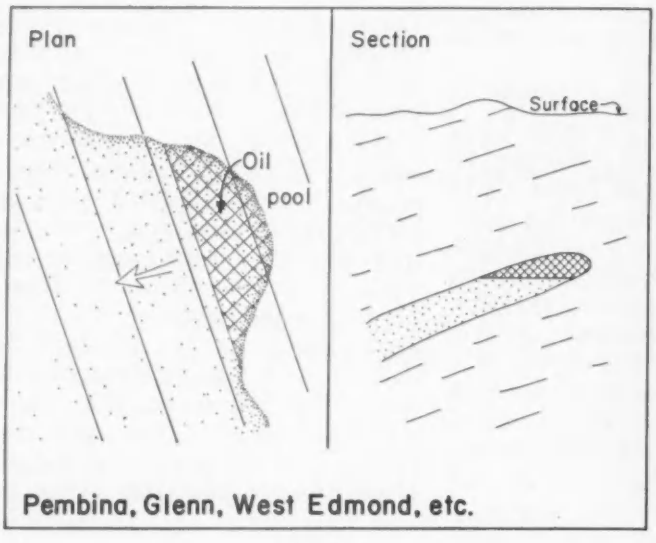


FIGURE 3

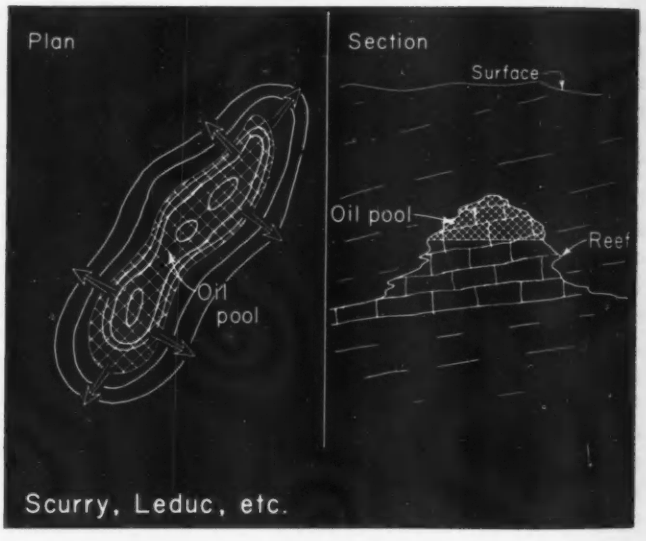


FIGURE 5

Oil pools in stratigraphic traps are hard to find . . .

They usually are marked by little or no local folding, faulting, or anything that can be determined from the surface. Finding them is a big problem for geologists, geophysicists and engineers. Shown here are several types of stratigraphic traps yielding oil.

buried faults, or tilted water tables may occur.

Many geologists are talking about "distributary sand channels," such as are forming now in the delta of the Mississippi River. Many long ridges of fine-grained sand, built up to 200 feet thick and extending for many miles, can be observed in the delta region today. Some formed under present conditions and others under past conditions of stream flow. Surface river systems concentrate the flow of the tributaries into a main river channel. The deltaic system distributes or disperses the sediments of the main river into many lesser channels.

Similar buried distributary channels occur in a number of places. Many of them contain oil pools. Some of the most striking are in the Seminole region of Oklahoma. There the distributary channels of the Booch sand form elongated sand deposits up to 200 feet thick, completely encased in shales. Some of the best shallow production of Oklahoma has been in the Booch sand. Knowledge that a sand is a distributary deposit instead of a normal stream deposit makes a powerful exploration tool.

A lot more will be heard about dolomite during the coming years. Dolomites look like limestones and are frequently classed with limestones as reservoir rocks. A dolomite, however, consists of magnesium and calcium carbonate. A limestone is chiefly calcium carbonate. There are all intervening gradations between dolomites and limestones. The reason for the importance of dolomites is that some dolomites are more porous and permeable than either limestones or other dolomites. A great many oil and gas pools are found in the dolomitic part of the reservoir rock. The adjacent limestone is found without any fluids. Thus, in many pools, both in stratigraphic and structural traps, that part of the reservoir rock above the water table is full of oil and gas if the material is dolomite but is dry or of very low productivity if limestone.

The dolomite that in general seems to be the most effective is carried in solutions that come in later along fractures or faults. It replaces the limestone and develops its own permeability and therefore its own supply channel. These same channels later become channels for oil and gas accumulation. The places where dolomite will replace limestone, then, become important places for exploration. One application of this is to redrill barren anticlines down the flanks. There faulting and fracturing might allow dolomite-bearing solutions to enter the dense limestones and replace them with permeable reservoir rock.

The dolomite problem is an old one in geology. There are still many elements of it that are not understood. A vast amount of new data is obtained from the sampling of closely spaced wells. Research geologists thereby have an unequalled opportunity of learning how dolomite forms, where it comes from, and especially how to predict where it will occur.

The identification of dolomite and sand patches and of channels such as these is certainly a work for experts. It can only be done successfully when time is given for careful and detailed study of much geological and geophysical data—all of which is expensive. Regional maps are necessary as the frame upon which to hang the detail maps needed to make a wildcat location. Accurate sampling and measurements of formations and careful records of the fluid content are essential. Along with the careful geologic work, freedom to drill more holes per discovery may be required.

Geology of fluids. Reservoir fluids is a subject that has been suddenly opened up to geologists. It promises to occupy an increasing amount of their attention in the years ahead. It has always been a subject of engineering interest. But petroleum geologists have only occasionally given it much serious consideration. They have been content to think mostly about the rocks and very loosely and academically as to the forces that place an oil pool where it is.

Geologists now find that the fluids in nature's plumbing system—the gas, oil, and water, standing or flowing in the minute, interconnected pore spaces of the rocks—are in an extremely delicate balance. And, what is of even more importance, that their movement and position can be predicted from data that can be obtained from modern drilling techniques or is already available. The pioneer work on this subject was done by M. King Hubbert. As with any new, fundamental concept, it set off many trains of thought as to its commercial application.

One application of the hydrodynamic concept is to the tilted water-table or displaced oil pool. These occur in areas where there is high topographic relief, as in California and the Rocky Mountains. The pool is found, not at the top of the anticline in its normal position, but down one flank. The pool, in fact, may be displaced completely off the top of the anticline, and is not found by conventional structural drilling.

Many More Drill Stem Tests Should Be Made . . .

Drill stem tests can be made to reveal stratigraphic traps and otherwise aid exploration.

They can point to oil accumulations by giving evidence on fluids, permeability, and pressure.

They should be used more frequently than merely in testing the producing ability of promising formations.

Pools pointed out by drill stem tests represent relatively low-cost discoveries.

Another application is redrilling local anticlines that were dry on top but located close by pools where production has resulted in large pressure sinks or man-made gradients. The Cairo pool of Arkansas is an example of one such discovery where the pressure decline from the neighboring Schuler field had nearly tilted the pool off the top of the Cairo dome, pulling the pool toward the area of decreased pressure.

Careful pressure analysis of reservoir rocks can also aid greatly in predicting nearness to the edge of stratigraphic traps, in determining the proximity to faults or permeability barriers, and in a much better ability to locate pool extensions, offshoots, and irregularities.

The applications of the delicate balance of fluids in motion in the reservoir rocks are being explored in many areas by many geologists. A body of empirical data is being developed that should be of great value in the years ahead. Three things can be said now.

1. The principle is as sound as Fort Knox.

2. The application is no better than the data upon which it is based. With correct data to work with, accurate predictions can be made. But, where the pressure measurements are poor, where the correlations are doubtful, and where the densities of the fluids are unknown, the predictions also are uncertain. As in subsurface geology, even a small amount of information is helpful, but for accurate predictions a large amount of accurate data is required.

3. Every dry structure, in areas of hydrodynamic reservoir conditions, must be reexamined to see whether the trap has been tested at a location logical on the basis of hydrodynamic factors; not structural alone.

Many geologists are talking about such things as hydrodynamics, pressure head, piezometric surfaces, tilted oilwater contacts, and displaced oil pools. A lot more will be heard about these phenomena in the future. There are many regions where past ideas of oil and gas accumulation are being completely revised.

The drill stem test is the key to many problems in reservoir fluids and also in stratigraphic traps. It has been extremely useful, but it promises to be far more useful in the future.

Three general kinds of information are obtained by the modern drill stem test: the kind of fluids present, the rate at which they enter the well or the transmissibility of the reservoir rock, and the pressure under which they occur in the reservoir. The operator is chiefly interested only in knowing if he has oil or gas, and if so, then some idea of the volume. The data he generally gets is largely qualitative and used to determine whether or not he sets pipe and tries to complete the well as a producer.

This is not enough for the geologist trying to find traps in an area where the fluids are in motion. He must also know the pressure accurately. From that he can calculate the height to which the water would rise in an open hole, or the pressure-head at the location. When several such pressure measurements are available, he can determine the direction of fluid flow. From that he can tell where a pool

will be located on any structure present in the area.

The geologist attempting to find stratigraphic traps is not happy, either, with the modern drill stem tests. The reason is that a drill stem test is not generally made unless there is enough evidence of oil and gas to offer some chance of the well being a producer. The presence of free water in a rock, however, is also important. It comes from a potential petroleum reservoir rock. The rate of inflow is a rough measure of permeability. If somewhere up the dip the same rock carries no free fluids, then in between is a good place to look for a stratigraphic trap. One of the best rules of thumb, in fact, is to move down the dip from a dry well, and up the dip from a wet well. Many prospects can be traced directly to the evidence on fluids, permeability, and pressure obtained from a drill stem test. This is a lot cheaper than the average $100,000 cost per prospect. For that reason alone, there should be many more complete drill stem tests with which to work.

Geologic history. There is more and more geological talk about geologic history as a guide to petroleum exploration. Geologic history, as a subject for study, is as old as geology. But the petroleum geologist has such an enormous amount of new data to work with, that geologic history takes on new meaning. Hollis D. Hedberg, one of America's leading petroleum geologists, recently stated:

"Recognize the physical essentials for oil pools, to be sure—source, reservoir, cover, and trap—and search out all available evidence regarding them. But bear in mind that not alone their existence but proper timing in their development may spell out the difference between a rich oil region and one which is relatively barren."

Geologic history is putting together, in chronological order, the various episodes to which the rocks, and especially the reservoir rocks, have been subjected. Human history quickly dims with age. Vast differences of interpretation, of critical data and of importance attach to every human episode. Is it any wonder, then, that the historians of the earth, dealing with millions and hundreds of millions of years, should disagree?

Studies of geologic history range from regional studies of whole continents down to local areas of a few square miles. The basis of the study is an almost innumerable number of maps of all kinds—sand, clastic ratio, structure, paleogeologic, facies, overlap, sub-crop, pressure, fluid and many others. The objective is to relate the location of oil and gas pools to the geologic history.

One of the chief applications of an understanding of the geologic history of a region is that certain episodes, for some reason or another, seem to be associated with the migration of oil and gas and their accumulation into pools. The time interval between the Mississippian and the Pennsylvanian eras, in the Mid-Continent region, for example, was a time of folding and faulting and many traps were formed. The tops of many of them were eroded away. The structures became "bald-headed." The incoming Pennsylvanian seas permitted a deposit, or "cap," of sediments to cover them over. This bit of geologic history seems to have been the setting for many hundreds of oil and gas pools in pre-Pennsylvanian rocks. One sees this same episode of history over and over result in oil pools. He is encouraged to believe conditions at that time were more favorable than at other times, and that this sequence of events deserves exploration. The key to understanding of the occurrence of the oil and gas at this, and in many other situations, is the geologic history involved.

Manpower. A common subject among geologists is where to look for the geological manpower that will be needed. If we are going to double our production and reserves we will have to double our geological staffs also. How? And the problem is not only one of quantity, but equally important is the quality.

Better geology should result in better exploration, cheaper production costs, and more discovery. When and if the petroleum industry really wants to speed up its discovery, one of the best ways will be to get more and better minds working in the exploration end of the business. The root of getting better minds is to get better professors in the schools. Not only does the good professor attract the good student, but he also influences the sharper minds to enter his field of study.

Getting better professors comes down largely to paying better salaries and giving better working conditions. As it is now, almost any good professor is constantly offered a higher salary from industry. He soon feels that his love of teaching is in effect giving a subsidy to education. He helps pay for education by working for less than his commercially minded colleague.

Keeping the good professors on the job is good oil business. It can be done by making outright gifts to schools to increase salaries, by endowing chairs in basic fields of study, or by giving summer and consulting employment to aid in the professors' yearly income. Just think what would happen if the petroleum industry would endow a few schools every year with chairs in such fields as geology, geophysics, physics, chemistry, and engineering, so as to attract the best teachers in the world!

Complete recovery. So far we have been talking about the traditional oil industry. We have, in addition, the possibilities inherent in converting such resources as the "tar" sands, the "oil" shales, the coal deposits, and the so-called "non-recoverable" oil into petroleum reserves. All of these are in various stages of development, generally close to being commercial. Of these, probably the most intriguing are the possibilities of still further increasing our recovery of petroleum from the pools that have been discovered.

Our petroleum resources are frequently broken down into primary, secondary, and tertiary reserves. Up to a few decades ago, the only recoverable reserves were the primary reserves. All the rest were termed non-recoverable. Then secondary recovery or "fluid-injection" methods came in. They took an ever-increasing percentage of the so-called non-recoverable oil and placed it on the market. The steady increase in efficiency of the secondary methods has recently been stated by Paul D. Torrey as follows:

"A realistic appraisal of the effect of improved recovery technology might be that sufficient additional oil will be produced by this means during the next 20 years to in large measure supplement the anticipated increased demand."

It has been estimated by a committee of the Interstate Oil Compact Commission that the total amount of oil discovered in the U. S. is on the order of 270 billion barrels. A help in

remembering this figure is that it is almost equal—barrel for dollar—to our National debt! Of this amount, only 88 billion barrels or 32 percent will ultimately be recovered by all known primary and secondary methods.

The great challenge to the petroleum industry today is to do a better job of recovery on the remaining 182 billion barrels—in fact to approach complete recovery. While we are shooting at the future, let's aim high! It is basically a job for the research teams—those "Cadillac" thinkers that have become an integral part of almost every large company's operation. The methods they have come up with so far are in the direction of heating and burning some of the oil in place and thereby driving out the remaining liquids. Many such teams of research workers are deep in the problem, and we can be sure that many schemes are on the drawing boards.

If we start with the premise that oil moved into a reservoir by some combination of physical, chemical, and geological forces, then we have a good reason to expect that some other combination of forces is able to remove this same oil. The best chance for a solution lies in a complete and thorough understanding of all of the natural phenomena involved in the reservoir. Like so many other operations of the industry, this is a job for the experts.

It is inconceivable that some way, both economical and practical, will not be worked out to get more or even all of the remaining oil out of the ground. Think what a recovery of 50 percent—or even of 10 percent—of the remaining 182 billion barrels would mean! We have seen over and over again where competition by many people has brought about the solution of countless of the so-called "unsolvable" problems of industry. The recovery of today's "non-recoverable" oil in the ground is no more difficult.

Not to be overlooked in the search for complete recovery is the accidental discovery of the solution. Wasn't it the accidental dumping of water into the Bradford reservoir which showed that water flooding increased recovery? And started the whole secondary recovery idea, which today accounts for nearly 20 percent of our production? If everybody in the industry is on the alert, there is certainly a good chance of finding the answer, either by sound, planned scientific methods, or by some fluke discovery overlooked by the heavy thinkers. We can travel in style. But we can also get there on a bicycle. If we take our time, we can get there on foot. So it is with the problem of complete recovery. There are several ways to arrive at a solution. The main element is that we shall keep alive an incentive to get there.

Areas. Sooner or later, all our ideas and techniques must be reduced to apply to specific areas and geologic conditions as we find them. Here we frequently encounter a factor that outweighs all other factors. It is the natural optimism or pessimism of the geologist. Some exhaust all of their ideas quickly and can see no more prospects in a region. They might be said to have a high permeability to pessimism. No matter how gloom-soaked and drilled-up an area becomes, there are always some imaginative geologists who still think prospects are to be found by anyone who will go in and do the necessary work. This generally means assembling vast amounts of fluid, pressure, reservoir, geophysical, and geological data. It means making a great many maps and sections. If one makes enough maps and sections, and puts enough thought to them, prospects will appear.

Each of the ideas and techniques that have developed in recent years, such as electric log analysis, fracturing, side-wall coring, micrologs, radiation logging, etc., has added its increment of new pools or increased production to each of the old districts. When we look at the U. S., then, it seems certain that discoveries will continue to be made in each of the present regions of production. Some will be made by presently known ideas. Others will be made by ideas yet to be uncovered. But to double our present production at the end of 20 to 25 years requires many really large discoveries. Some examples of regions that could produce large pools, fields, and provinces, based on what we know now, are briefly listed. Others will show up with new ideas, new techniques, and new discoveries. Our situation is dynamic.

1. The stratigraphic trap possibilities of the California basins, of the Rocky Mountain region, around the salt plugs of the Gulf Coast, and of the Appalachian basin are tremendous. They have been described many times by many geologists. Past drilling has been chiefly confined to the crests of the anticlines. But when we see stratigraphic trap pools like Pembina in Canada and East Texas in the U. S., some idea may be gained of what can yet be uncovered by non-structural drilling.

2. There are literally hundreds of anticlines that have been drilled and found dry or barren on the crests, especially in the Rocky Mountain region. Some undoubtedly will hold pools displaced down their sides or along the plunge. An understanding of the effects of pressure-head gradients and the flow of reservoir water on the location of oil pools in such an environment offers a definite way to discover them.

3. Many regional analyses can be made that suggest areas where new provinces might occur. One, by way of example, is east of the Mississippi. A dozen others of a similar nature come to mind.

The distribution of the Ordovician and Cambro-Ordovician formations is shown in Figure 1. The areas that have been productive are shown in black. Most productive areas coincide with dolomitic replacements of the limestone, thereby providing both channels for the accumulation of oil and also the reservoir space to hold it. These Cambro-Ordovician and Ordovician rocks are equivalent to the highly productive Viola Limestone, Simpson sands, and Arbuckle and Ellenburger limestones and dolomites of the Mid-Continent.

Away from the productive areas shown, the density of drilling that penetrates the Ordovician is exceedingly low. Experience in the Mid-Continent shows the importance of such unpredictable features as unconformities, old folding, dolomitization, buried faulting, and facies changes in localizing oil pools. Even our present slight knowledge of the Cambro-Ordovician east of the Mississippi River shows that all of these features occur. It seems logical to expect that more drilling will uncover more of these features. It is in the cards, in fact, that this group of rocks might contain a pool the size of the East Texas pool—or an East Texas times ten—or several of them. We will never know unless we drill a lot more wells.

ACKNOWLEDGMENT

From a paper, titled "Geologists Are Talking About," presented before the Independent Petroleum Association of America at St. Louis, November 1, 1955.

Good Prospects—a Big Survival Problem for the Small Operator

Limited budget demands careful choice of geological assistance as well as close attention to problem of concentrating his exploration activities.

By DANIEL A. BUSCH
Consulting Geologist, Tulsa

APPROXIMATELY 90 PERCENT of the oil discoveries made in the U. S. each year are attributable to the courage and imagination of independent operators. It is noteworthy, however, that they control less than one-half of the known reserves. To control large reserves requires immense sums of capital tied up in lease bonus and rental payments.

There are two principal types of operators among the independents, namely those who invest (or reinvest) oil capital and those who invest non-oil capital. Among the first group are the numerous small independent producers who may operate either as individuals, partners, or under the requirements of a small integrated corporation. The second group is comprised largely of individuals, generally living in large metropolitan areas, who are investing personal capital in oil ventures as a means of using up surplus profits derived from other types of business. Many wealthy industrialists, real estate men, lawyers, motion picture people, etc., fall into the group having non-oil capital which they wish to invest in speculative oil ventures. These two groups of independent operators have one problem in common, namely, competing with the major oil companies with their diversified technical specialists and extensive financial resources. A major oil company usually employs experts (by training) in exploration, production, transportation, refining, and marketing. The small independents, on the other hand, are fortunate if they have more than one or two experts in any of these phases of the petroleum industry. How is it then that the independents have been able to survive such competition?

Discovery comes first. The key to the success of any oil company, whether it be a major operator or a small independent, lies in its ability to discover and develop new reserves. All other aspects of the business are secondary to their ability to *find* oil. Without the ability to find oil there is only limited need for accountants in this business. Production, transportation, refining, and marketing present no problem if there is no crude to process. The most successful small operators generally are long on oil-finding "know-how" and subordinate all

How the small operator survives . . .

1.	**The most successful small operators generally are long on oil-finding know-how . . . and subordinate other aspects to this effort.**
2.	**For best exploration program . . . detail geology of limited area . . . but watch developments over large area . . . be free to shift to promising areas.**
3.	**Best chance of top-flight geological advice is to hire a full-time geologist . . . or retain one on part-time basis.**

other aspects of their business to this one effort.

It is frequently said that "oil is becoming more and more difficult to find." Huge reservoirs, such as have been developed at East Texas, Oklahoma City, Rangely, etc., become progressively more difficult to find with each such discovery, but new ideas, data, and techniques tend to offset this situation with respect to discovery of smaller reservoirs. In the exploration departments of the major oil companies there are geological personnel assigned to long range basin studies, others to small areas, and still others to well site work. Much of the exploration thinking has to do with finding more structures which are becoming less abundant with each such prospect drilled. Ninety-five percent of geophysical efforts are directed to either finding new structures or confirming geological structural interpretations.

The significance of the stratigraphic trap type of accumulation is readily admitted by all such personnel, but very little is really done about it. There are several reasons for this, namely:

- Few university professors have had *any* experience at finding stratigraphic traps, therefore, students are seldom equipped with the necessary "know-how" when they graduate.
- Many "old time" geologists (now in administrative positions) know little about finding "strat" traps.
- Management is much more readily sold on "closed contours" than on wedgeouts up dip on a monoclinal slope.

Survival problems confronting the small operator are quite different from those of the major. First, he operates on a much more limited budget. This tends to sharpen his thinking and it follows that he must be much more scrutinizing in his selection of acreage plays. Since geophysical exploration is expensive, that type of exploration for structures is kept at a minimum. That leaves geology as the prime scientific exploration tool available to the small operator. As a result those small operators who use science at all tend to rely much more on geology than geophysics.

The majority of the small operators using geological talent have several types of geological services available to them. They frequently hire experienced men away from the majors who bring with them ideas gained while previously employed. Due to limited physical facilities, restricted budgets, and few personnel, geologists so employed have much greater responsibilities heaped on them than ever before. They, therefore, are obliged to screen their prospects much more closely and to keep their science in balance with the economics that are involved. The responsibility for dry holes is not lost in the maze of higher echelons that tend to characterize large company operations. The failure or success of a wildcat venture is clearly traceable to one or two key personnel—usually the geologist.

Many small operators do not believe they can afford the questionable luxury of a full-time geologist and therefore employ consulting geologists on a piecemeal basis. If the consulting geologist is successful in one or more of his early assignments he might expect repeated demands for his services from those clients who experienced success from his recommendations. Due to the high ratio of wildcat failures, which is a hazard inherent to the business of finding oil, the small operators who engage consultants tend to play the field. They, perhaps unwittingly, are looking for the man who can solve all their oil-finding problems. A third method, readily available to the small operator, is to engage a well qualified geological consultant on a retainer basis. By such an arrangement he is in a position to see many of the plays or ideas of a geologist whose prime concern is that of generating ideas and plays. Such geologists are seldom burdened with either administrative duties or paper shuffling. They are consultants because they choose to pursue geology as a profession and not as a stepping stone to an administrative post.

Many independents use a minimum of geology and merely rely on their own judgment as to the merits of a play. Their chances of success, however, are something less than that of playing a roulette wheel or investing large stakes in a bingo game. The independent's best chance of having the benefits of the geological profession is to either hire a well-qualified full-time geologist or retain one on a part-time basis who is available when needed. Such a man should not be responsible for most of the leasing and well sitting assignments, but free to work on both regional and detailed geological studies. Such studies should have but one objective, mainly, finding and defining drillable prospects. He should be available likewise to screen acreage and drilling deals submitted from outside sources. Many such deals submitted by land brokers are of questionable merit. Once the promoter realizes his prospect is to be subjected to a scientific check and approved *before* management will pass on the economic aspects of the deal, the volume of such prospects will diminish. This will afford more time to both the geologist and the executive for creative endeavor.

Exploration methods. Many independent operators concentrate their exploration activities in one or two localized areas, whereas others carry on very widespread operations. Both modes of operation have merit. Confining one's early efforts to a limited area of, say, several active counties is probably preferable to spreading out, especially if the exploration staff is limited to one geologist. With only one geologist it usually is better to know all there is to know about the productive possibilities of a limited area rather than have a general knowledge of a broad area. Perhaps the best program is one of detailing the geology of a limited area and watching developments over a large area, being free to shift into new areas which show promise of being attractive by virtue of one or more significant discoveries.

The small independent seldom is in a position to compete with the majors for large acreage plays because of his much more limited capital. He frequently is obliged to lease small tracts and/or obtain farmouts from the majors. In so doing he is obliged to wildcat from a much smaller protective acreage position than the majors could justify. This is one of the main reasons why the independents drill so many wildcats and why their exploration activities are so essential to a well-balanced economy in the petroleum industry. It behooves the major oil companies to continue their farmout programs, dry hole, and acreage contributions. In this way they, too, can benefit materially from the small efforts of the independents who collectively contribute so much to a healthy industry. —**The End**

Ways to solve the problems of . . .

Employing the College Graduate

Interviewers and placement officials speak out on how oil companies and colleges can work together to expedite employment and increase applicants.

THE ANNUAL "student rush" is on. From February through April hundreds of oil company interviewers have visited—and will visit—college campuses across the nation. Each interviewer has but one objective: Fill those job vacancies—and fill them with top calibre men.

In 1956 it will be harder than ever to find top calibre personnel. There will be approximately 26,000 engineering and science graduates to fill an industry need for over 40,000. To say that competition will be keen is putting it mildly.

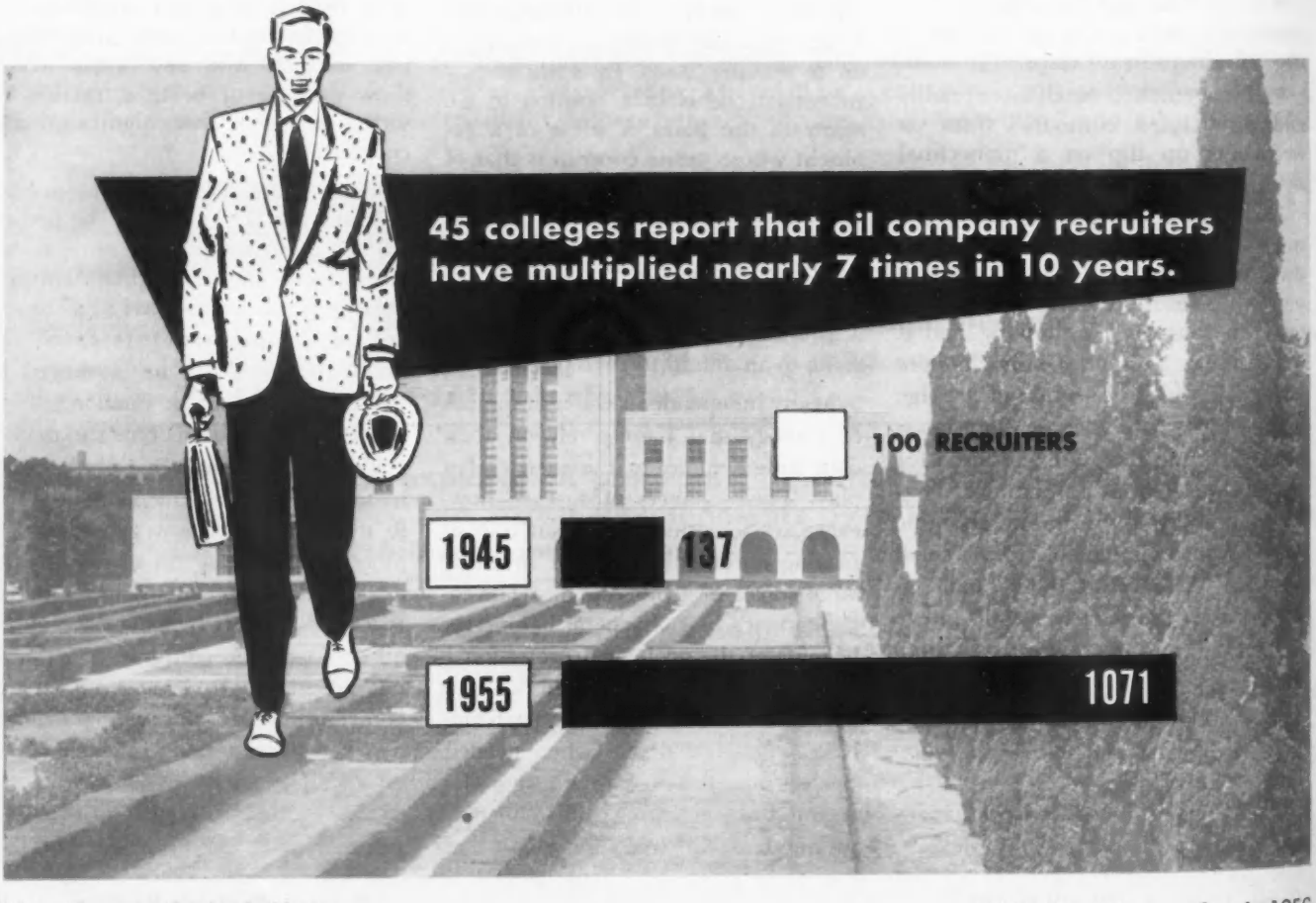
There has been a phenomenal growth in industrial recruiting of college graduates in recent years. It has become big business.

With the need and supply at such odds, no crystal ball is needed to see why industry is stampeding to the campuses. Last year, one group of 15 oil companies hired 1725 graduates through student interviews, compared with 386 in 1945. Out of 35 oil companies queried, 23 or nearly two-thirds have been using the college interview method of hiring for 10 years or less. Seven have been interviewing for less than five years.

The oil industry is but one of many that have jumped on the college interview bandwagon—and there are more to come. In fact, the trend toward college interviews has increased at such a phenomenal rate it has produced countless problems for interviewers and placement officials alike.

The following report is the result of a comprehensive survey conducted by WORLD OIL to determine what the major college interviewing problems are—and ways to solve them. It is intended to provide information and ideas that will benefit both the interviewer and the college placement director.

This is what 45 colleges and 35 oil companies have to say about modern day college interviewing practices.



20 suggestions from placement directors to interviewers . . .

1. Well in advance of campus visit, provide the College Placement Bureau with definite information concerning: (a) Plans for visit and time of arrival. (b) Campus schedule. (c) Number and type of graduates wanted. (d) Complete description of job openings, including type of work, location, salary and advancement possibilities. (e) Plans for faculty conferences. (f) Number and names of representatives who will visit the campus. (g) Handling of application forms in advance of arrival. (These points were mentioned by 26 of the 45 colleges replying.)

2. Make all arrangements for campus visits at least one month in advance. Some colleges requested three to six months notice. (21 mentions.)

3. Notify student promptly on decision. Send duplicates of correspondence to the Placement Bureau. (21 mentions.)

4. Provide well qualified interviewers who: (a) Know and like their work. (b) Have full understanding of college-age people. (c) Are well informed about job openings. (d) Are familiar with all phases of their company's operations. (e) Know how to conduct interviews. (17 mentions.)

5. At least two weeks in advance of visit, send factual company literature and brochures in quantities that meet the situation. Not so numerous or voluminous as to require an excessive amount of space for display, and reading time on the part of the student. (12 mentions.)

6. Organize program with one central office for entire company and subsidiaries, rather than on departmental or intercompany basis. (12 mentions.) *Editor's Note: Colleges fail to realize that the oil industry is highly specialized—that refining, production, exploration, pipe lines are separate industries. An experienced refinery engineer could hardly be expected to interview candidates for the production division.*

7. Interviewers arrive on time and stay strictly within their schedule—with no last minute changes. (10 mentions.)

8. Conduct all business in a direct manner both with the Placement Bureau and the students—using no unethical tactics. See Code of Ethics for Interviewing Procedures, 1949 Issue of Journal of Engineering Education. (8 mentions.)

9. Keep in mind that successful recruiting is almost always tied in with good faculty relationships. Keep in personal contact with Placement Bureaus and college departments during the off season. (4 mentions.)

10. After interviews return to the Placement Office for discussion of candidates before leaving. (4 mentions.)

Other Mentions:

11. Do not ask Placement Directors to make decisions on candidates.

12. Understand the limitations of placement facilities and do not ask the impossible.

13. Arrange for students to make plant visits during class breaks and holidays.

14. Arrange campus recruiting program for June seniors and interview between February and April.

15. College interviewers should familiarize themselves with degrees offered by any given school before writing for interview arrangements.

16. Interviewers should give sufficient weight to part-time work and extra-curricular activities which might have a tendency to lower grade point averages.

17. Courtesy should be shown to the "average" candidate as well as the outstanding one. He should also be given the same type of interview.

18. The ideal interviewing group consists of one technical man and one personnel man.

19. The college interviewer program should be flexible enough to fit into any campus situation.

20. Interviewers should be thoroughly conversant with company arrangements with the Placement Bureau.

20 suggestions from interviewers to placement directors . . .

1. Interviewing rooms should be private and of adequate size. (This point was mentioned by 24 of the 35 companies replying.)

2. Provide complete records and background information on students to be interviewed. (15 mentions.)

3. Keep an orderly appointment schedule. (10 mentions.)

4. Maintain a staff large enough to coordinate visit details with department heads and to meet interviewer needs before, during and after the interviews. (8 mentions.)

5. Provide for conferences with professors regarding job candidates (6 mentions.)

6. Provide a good placement library with an adequate reading room. The library should have various job opportunities cross referenced by industry, job location, job title and degree requirements. (6 mentions.)

7. Have a well-coordinated communications system to insure student notification of company visit, and type of interview. (5 mentions.)

8. Placement bulletin boards should be well organized and of sufficient size to clearly show all company announcements of campus interviews. (4 mentions.)

9. Furnish information in advance about meals, lodging, parking and campus geography. (3 mentions.)

10. See that students fill out application forms before interviewer arrives on the campus. (3 mentions.)

Other Mentions:

11. Closer contact between department heads and Placement Bureaus regarding industry requirements.

12. Proper indoctrination of students as to correct interview practices.

13. Some pre-screening of candidates—if possible.

14. Require students who sign up for interviews to keep appointments.

15. Make provisions for the interviewers to visit the various departments.

16. Notify the company if no one is available for interviews.

17. Keep an impartial attitude toward companies when referring students for jobs.

18. Provide facilities for meetings with the faculty.

19. Help the recruiters contact members of the faculty, and make necessary arrangements for lunch on campus.

20. Provide advisory and counseling services for the student so he will know the companies that offer him the kind of future he seeks.

Continued on Page 92

College placement directors speak . . .

Q *When did your college start its placement program?*

A Fifteen, or one-third of the colleges replying have established placement bureaus since 1945. Six have been in existence five years or less.

Q *Approximately how many oil company interviewers visited your campus during the 1954-55 school year?*

A Of the 45 colleges replying, 11 reported 137 oil company interviewers visited their campuses in 1945. During the last school year, 1071 oil company interviewers visited 34 of the campuses. One college reported 350 oil representatives visited its campus last year, compared with 50 in 1945.

Q *Have you increased your facilities for company interviews since 1945? To what extent?*

A Forty-three colleges reported considerable expansion of placement facilities and personnel in the past 10 years. Two said no improvement has been made. One placement director said he needs to triple space and number of personnel.

On the other hand, one of the colleges has increased its personnel from 1 to 12 and has 10 times as much office space as in 1945. During the same period job listings have increased from 1 to 3000, placements have increased from 100 to 10,000 and the number of campus interviews has increased from 1 to 250. Another college has tripled its space and expects to triple its present space and personnel within the next three years.

Q *Approximately how many of your students were interviewed by company representatives during 1954-55? How many were hired?*

A Thirteen colleges reported 1161 graduates were interviewed for positions in the refining industry—86 were hired; 8 colleges reported 550 graduates were interviewed for jobs in the petrochemical field—23 were hired; 11 colleges reported 482 graduates were interviewed for pipe line work—51 were hired; 20 colleges reported 1202 graduates were interviewed for jobs in exploration and production—78 were hired.

Q *Has there been a shift in emphasis in the type of student hired?*

A Forty-four colleges said "yes." One said "no." Nearly all agreed there has been a decided increase in demand for engineers, chemists and accountants—particularly in the past five years. One college reported than in 1955, demand for engineers was 5 times the supply, scientists 10 times the supply and accountants 5 times the supply. Another college said each of its graduates in these three fields had at least 10 to 15 job offers.

Twenty colleges say there has been a corresponding increase in demand for liberal arts majors and salesmen in the past three years.

Q *What are the most common faults of company interviewers?*

A 1. Do not properly define qualifications for applicants in advance.

2. Do not inform the college of company decisions. (Numbers 1 and 2 were mentioned many more times than the others as the major faults.)

3. Do not inform the candidate of company decisions (if not hired).

4. Send too much promotional material to the college.

5. Do not properly announce time of arrival or departure.

6. Ask the placement director to make the decision on applicants.

7. Exert pressure on the placement director to get preference in graduate selection.

8. Rude to students.

9. Show prejudice because of racial or religious background.

In almost every instance, placement directors emphasized that the majority of the companies are doing an exceptional job of recruiting. Several colleges mentioned that the federal government is by far the weakest of them all in recruiting practices—sends too many people to interview and stays too long; too much duplication of effort.

One college mentioned that an oil company showed great interest in eight applicants, but never again contacted the students or the placement bureau. **Continued on Page 97**

TEN WAYS TO GET STUDENTS TO ATTEND INTERVIEWS

1. **Contact the placement bureau of the college well in advance of the visit and send literature for distribution to students and faculty. *(Most companies replying use this method only.)***
2. **Keep dormitories, fraternity and sorority houses on the mailing list for company material.**
3. **Personal contact throughout the year with the placement bureau and college department heads.**
4. **Conduct year-round public relations program with placement personnel, deans of engineering and the engineering library.**
5. **Advertise in campus newspapers.**
6. **Send copies of all correspondence concerning interviews to department heads as well as placement bureau.**
7. **Send interview notices for posting on college bulletin boards.**
8. **Take active part in placement association work.**
9. **Conduct group meetings whenever possible.**
10. **Sponsor summer employment programs for juniors. They usually discuss the company when they return to college in the fall.**

College interviewers speak . . .

Q *How many colleges did you visit during the 1954-55 school year?*

A One company visited only two colleges while another conducted interviews at 158 schools. The average was 35 colleges.

Q *How many colleges have placement departments? How does this compare with 1954?*

A Most of the companies said all the colleges they contacted had placement facilities of one kind or the other. However, one of the larger companies said that 100 out of 158 colleges contacted had a placement bureau—another reported 130 out of 142. The interviewers all agreed that there has been a remarkable increase in placement bureaus in the past 10 years. One company said there are twice as many.

Q *How many students did you interview for oil company positions? How many were hired?*

A
- Seven companies interviewed 3093 students for positions in the refining industry (one company alone interviewed 2817 students and hired 200). A total of 226 were hired.
- Five companies interviewed 1102 students for petrochemicals—86 were hired.
- Twelve companies interviewed 1432 students for jobs in exploration and production—152 were hired.
- Five companies interviewed 213 students for pipe line jobs—19 were hired.

Q *Is there a trend to improve college placement services?*

A No doubt was left here. Nearly all the companies said college officials are constantly trying to improve their service to students and interviewers alike. There is a need in some colleges to enlarge facilities and increase personnel. Several interviewers mentioned that representatives of industry and college placement officials meet annually to discuss ways of mutual improvement. Placement associations are the sponsors of most of these meetings.

Q *How long does it take to conduct a college interview?*

A Eleven companies said it takes 30 minutes to conduct a successful interview. Seven said 20-30 minutes. Five complete their interviews in 20 minutes. One interviewer said it takes only 10 minutes per interview while another said it takes from 30 to 45 minutes.

Q *Is the interviewee hired by directly contacting the individual, or through the placement bureau?*

A Twenty companies reported that they contact the individual directly when he is hired. Four companies hire through the placement bureau. Three companies make direct contact with the individual, but keep the placement bureau fully informed (many of the companies that contact the individual directly also contact the placement bureau).

Q *What success have you had in getting prospects to attend interviews?*

A Eighteen companies say they have good to excellent success in getting students to attend interviews. Seven companies report fair success—two say attendance is poor.

Q *Has there been a shift in emphasis on the type of students hired?*

A Thirty of the companies said "yes." Major shift has been to mechanical and chemical engineers, chemists and accountants, resulting in the current shortage of graduates in these fields. Five said there was no change of emphasis.

Q *What are the most common faults of college placement departments?*

A
1. Do not properly inform students about job openings. (Was mentioned more times than any other as the major fault.)
2. Do not provide adequate student records for interviews.
3. Do not provide proper facilities for interviews.
4. Do not circulate company literature properly.
5. Do not screen applicants properly in advance.
6. Show lack of interest in cooperating with interviewers.
7. Lack of centralized placement office.
8. Fail to notify interviewer if less than a minimum number of students are available for interviews.
9. Do not follow up to make sure students report for interviews.

The interviewers were unanimous in their general praise of placement bureaus. Many emphasized that the schools have done an outstanding job considering the recent heavy demand on limited facilities and personnel in some of the colleges. Where weaknesses are found they usually can be attributed to overloaded personnel or misplaced personnel in charge, i.e., the associate professor whose interests are solely academic is assigned placement responsibilities in addition to his other duties.

WHAT INTERVIEWERS SEEK IN GRADUATES

1. **Grades—intelligence—mental alertness.** ***(Mentioned by 26 of the 35 companies replying.)***
2. **Personality.** ***(15 mentions.)***
3. **Appearance.** ***(15 mentions.)***
4. **Interest—mental curiosity.** ***(14 mentions.)***
5. **Maturity.** ***(14 mentions.)***
6. **Character traits.** ***(12 mentions.)***
7. **Extra-curricular activities.** ***(8 mentions.)***
8. **Experience.** ***(5 mentions.)***
9. **Family background.** ***(4 mentions.)***
10. **Attitude.** ***(4 mentions.)***

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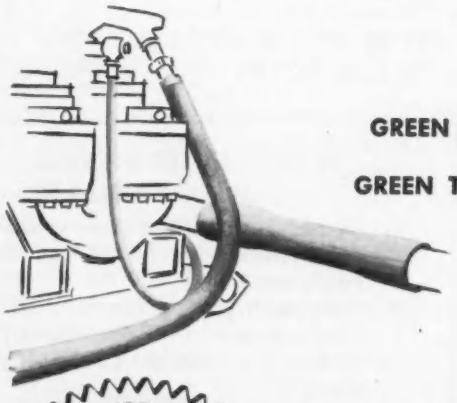

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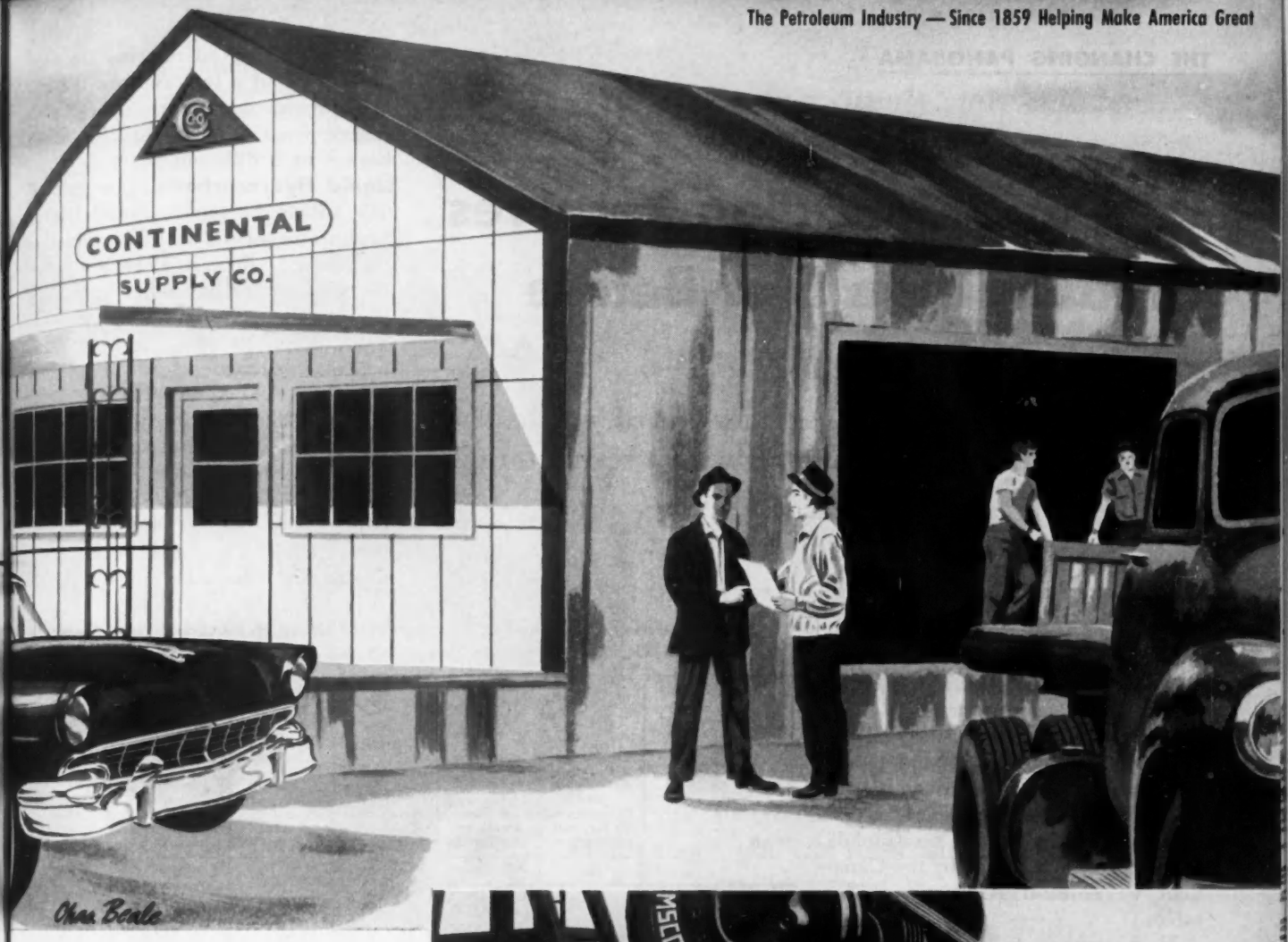

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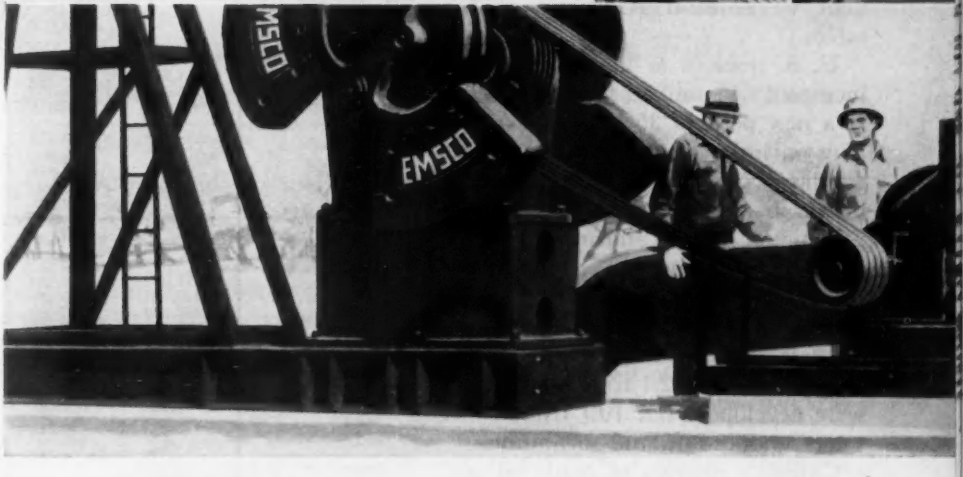

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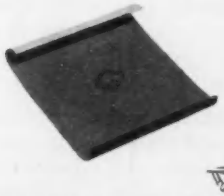

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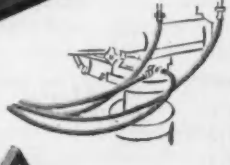

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SERVING THE OIL AND GAS INDUSTRIES

U. S. and Canadian Reserves Greater Than Ever Before

More oil and gas was proved up than was consumed in 1955. But results show that search for oil is becoming more difficult and expensive.

OPERATORS PROVED up more oil and gas reserves in the U. S. and Canada in 1955 than the record breaking volumes consumed.

These results were revealed by the recently released joint annual report on reserves by the American Petroleum Institute and the American Gas Association. The figures on Canada were reported originally by the Canadian Petroleum Association. (See tables.)

U. S. reserves of liquid petroleum increased 645 million barrels in 1955 to a new peak of 35.4 billion barrels. This includes crude oil and natural gas liquids. Operators proved up 3.3 billion barrels of new reserves. But 2.7 billion barrels meanwhile were produced. Natural gas reserves shot up by 12 trillion cubic feet to a new high of 223.7 trillion. That was the greatest annual increase since 1946. New reserves of 22.1 trillion cubic feet were developed. But 10.1 trillion feet were produced in the meantime.

Canada's reserves of crude oil and natural gas liquids increased 341 million barrels to a new peak of over 2.7 billion. Operators developed 470 million barrels of new reserves while producing 130 million.

Commenting on U. S. reserves, the API said, "The net results shown are on the favorable side. But they serve to point up further the repeated statements of oil men. They declare that the search for oil is becoming more difficult and more expensive with each passing year."

The Institute noted that the industry drilled more than 56,000 wells in 1955, a record number. Yet the net increases in proved reserves are only moderate and a far cry from the immediate postwar years. They then ranged from 1 billion to 2½ billion barrels in 5 different years.

Liquid Hydrocarbons. The gain of 645 million barrels in liquid hydrocarbon reserves in 1955 exceeded that of 422 million in 1954. But it was the smallest for any other year since World War II, when there was far less drilling. In other postwar years, net increases ranged from 700 million barrels in 1947 to 2.6 billion in 1951.

The 3,385,232,000 barrels of new liquid hydrocarbon reserves proved up in 1955 compared with 3.0 billion in 1954, a postwar low of 2.7 billion in 1947, and a postwar high of 5.1 billion in 1951.

Crude Oil. Included in the U. S.

TABLE 1—Estimated Proved U. S. Reserves of Liquid Hydrocarbons, by Years
Sources: Crude, API; Natural Gas Liquids, API and AGA . . . Thousands of Barrels

YEAR	NEW OIL ADDED DURING YEAR: Through Revisions of Previous Estimates and Extensions to Known Fields (1)	Through Discoveries of New Fields and of New Pools in Old Fields (2)	Total Through New Discoveries Extensions and Revisions (Columns 1+2) (3)	[1] Production During Year (4)	Estimated Proved Reserves as of End of Year (Column 3-4) (5)	Increase Over Previous Year (6)
[2]Crude Oil & Condensate						
1936	.....	.....	.....	.....	**13,063,400**	.....
1937	2,792,790	928,742	3,721,532	1,277,664	**15,507,268**	2,443,868
1938	2,243,571	810,493	3,054,064	1,213,186	**17,348,146**	1,840,878
1939	2,058,455	340,667	2,399,122	1,264,256	**18,483,012**	1,134,866
1940	1,607,012	286,338	1,893,350	1,351,847	**19,024,515**	541,503
1941	1,538,989	429,974	1,968,963	1,404,182	**19,589,296**	564,781
1942	1,618,925	260,051	1,878,976	1,385,479	**20,082,793**	493,497
1943	1,202,368	282,418	1,484,786	1,503,427	**20,064,152**	—18,641
1944	1,556,192	511,308	2,067,500	1,678,421	**20,453,231**	389,079
1945	1,690,315	419,984	2,110,299	1,736,717	**20,826,813**	373,582
Crude Oil Only						
1944	.....	.....	.....	.....	**19,784,530**	.....
1945	.....	.....	.....	.....	**19,941,846**	.....
1946	2,413,628	244,434	2,658,062	1,726,348	**20,873,560**	931,714
1947	2,019,140	445,430	2,464,570	1,850,445	**21,487,685**	614,125
1948	3,398,726	396,481	3,795,207	2,002,448	**23,280,444**	1,792,759
1949	2,297,428	890,417	3,187,845	1,818,800	**24,649,489**	1,369,045
1950	1,997,769	564,916	2,562,685	1,943,776	**25,268,398**	618,909
1951	4,024,698	389,256	4,413,954	2,214,321	**27,468,031**	2,199,633
1952	2,252,860	496,428	2,749,288	2,256,765	**27,960,554**	492,523
1953	2,704,450	591,680	3,296,130	2,311,856	**28,944,828**	984,274
1954	2,287,231	585,806	2,873,037	2,257,119	**29,560,746**	615,918
1955	2,393,767	476,957	2,870,724	2,419,300	**30,012,170**	451,424
[3]Natural Gas Liquids						
1946	.....	.....	.....	.....	**3,163,219**	.....
1947	192,237	59,301	251,538	160,782	**3,253,975**	90,756
1948	405,874	64,683	470,557	183,749	**3,540,783**	286,808
1949	294,211	92,565	386,776	198,547	**3,729,012**	188,229
1950	707,879	58,183	766,062	227,411	**4,267,663**	538,651
1951	648,497	75,494	723,991	267,052	**4,724,602**	456,939
1952	475,170	81,668	556,838	284,789	**4,996,651**	272,049
1953	648,047	95,922	743,969	302,698	**5,437,922**	441,271
1954	20,830	86,520	107,350	300,815	**5,244,457**	—193,465
1955	447,160	67,348	514,508	320,400	**5,438,565**	194,108
[4]Total Liquid Hydrocarbons						
1946	.....	.....	.....	.....	**24,036,779**	.....
1947	2,211,377	504,731	2,716,108	2,011,227	**24,741,660**	704,881
1948	3,804,600	461,164	4,265,764	2,186,197	**26,821,227**	2,079,567
1949	2,591,639	982,982	3,574,621	2,017,347	**28,378,501**	1,557,274
1950	2,705,648	623,099	3,328,747	2,171,187	**29,536,061**	1,157,560
1951	4,673,195	464,750	5,137,945	2,481,373	**32,192,633**	2,656,572
1952	2,728,030	578,096	3,306,126	2,541,554	**32,957,205**	764,572
1953	3,352,497	687,602	4,040,099	2,614,554	**34,382,750**	1,425,545
1954	2,308,061	672,326	2,980,387	2,557,934	**34,805,203**	422,453
1955	2,840,927	544,305	3,385,232	2,739,700	**35,450,735**	645,532

[1] See footnote to Table 2. [2] Includes cycle plant and lease condensate. [3] Condensate, natural gasoline, and liquefied petroleum gases. [4] Crude oil and natural gas liquids.

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"You mean it actually costs less to run casing with FLEXIFLOW?"

"That's right... because Flexiflow fills the casing automatically as it is being run, you save the time required to fill the casing at the surface. And what's more, you can run casing at a faster rate, without fear of damaging the formation with high-pressure surges. With Flexiflow, casing running times can be reduced by as much as one-third. That's why it costs much less overall to run casing with Flexiflow."

Flexiflow's Flexible Flow-Control Diaphragm *automatically* adjusts itself to compensate for increases in pressure—automatically relieves harmful pressure surges before they can act on the formation. The higher the pressure from below, the more the hole through the diaphragm expands. And after the first few joints of casing have been run, the hole expands to the point where a joint is filled as each new joint is run. This, of course, is the condition that provides maximum relief from pressure surges (Ram effect). After each joint is run, the hole returns to its original diameter, controlling the fill and preventing overfill of the casing.

Another very important fact about the pressure-relief provided by Flexiflow, is that, in addition to minimizing the danger of breaking down a potential lost circulation zone and setting up a possible bad cement job, the chances are very good that you are at the same time *protecting the producing life of the well.* Pressure surges, created by the use of conventional floating equipment under certain conditions, drive a portion of the well fluid into the formation and tend to "mud-off" the producing zone. This can seriously cut down the production of a well. By using Flexiflow to relieve these pressure surges you are actually protecting the producing formation.

Baker Flexiflow Fill-Up Shoes *(Product No. 160)* and Collars *(Product No. 161)* provide all of these protective features and, in addition, contain the time-tested ball-type back-pressure valve for cementing.

Available now at your supply store, Flexiflow Equipment may be obtained in either conventional form or with the added feature of Baker exclusive Whirler Ports *(Product Nos. 162 and 166)*. Uniform distribution of the cement as it is pumped from the shoe or collar can be as important as having the casing centered in the hole. These whirler ports provide added assurance of getting that uniform distribution, since the cement is forced around and around the casing as it leaves the shoe, minimizing the possibility of channeling.

Baker Fill-Up Equipment, conventional or whirler, used in proper combination with Baker Casing Centralizers and Baker Wall Scratchers, provides you with maximum assurance of successful primary cementing.

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Baker Flexiflow Fill-Up Collars and Shoes
Baker Casing Centralizers
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liquid hydrocarbon reserves at end of 1955 were 30,012,170,000 barrels of crude oil. That amount was 451,424,000 barrels more than at end of 1954. The industry proved up 2,870,724,000 barrels of new reserves in 1955 while producing 2,419,300,000. The net gain of 451 million barrels in 1955 was the smallest since World War II. In 1954 the increase was 616 million barrels. In other postwar years, increases ranged from 500 million barrels in 1952 to 2.2 billion in 1951.

The 2,870,724,000 barrels of crude reserves proved up in 1955 was practically the same as for 1954. It compared with a postwar low of 2.5 billion barrels in 1947 and a postwar high of 4.4 billion for 1951.

Natural Gas Liquids. U. S. reserves

TABLE 2

Summary of Changes in 1955 in Proved U. S. Reserves of Liquid Hydrocarbons

Sources: Crude oil from API; natural gas liquids from API and AGA

(THOUSANDS OF BARRELS)

CRUDE OIL		
Total proved reserves Dec. 31, 1954		29,560,746
Revisions of previous estimates	+696,114	
Extensions of old pools	1,697,653	
New reserves discovered in 1955 in new fields and in new pools in old fields	476,957	
Proved reserves added in 1955		2,870,724
Total proved reserves Dec. 31, 1954 plus new proved reserves added in 1955		32,431,470
*Less production during 1955		2,419,300
Total proved reserves Dec. 31, 1955		30,012,170
Change in reserves during 1955		+451,424
NATURAL GAS LIQUIDS		
Total proved reserves Dec. 31, 1954		5,244,457
Revisions of previous estimates and extensions of old pools	+447,160	
New reserves discovered in 1955 in new fields and in new pools in old fields	67,348	
Proved reserves added in 1955		514,508
Total proved reserves Dec. 31, 1954 plus new proved reserves added in 1955		5,758,965
*Less production during 1955		320,400
Total proved reserves Dec. 31, 1955		5,438,565
Change in reserves during 1955		+194,108
TOTAL LIQUID HYDROCARBONS		
Total proved reserves Dec. 31, 1954		34,805,203
Revisions of previous estimates and extensions of old pools	+2,840,927	
New reserves discovered in 1955 in new fields and in new pools in old fields	544,305	
Proved reserves added in 1955		3,385,232
Total proved reserves Dec. 31, 1954 plus new proved reserves added in 1955		38,190,435
*Less production during 1955		2,739,700
Total proved reserves Dec. 31, 1955		35,450,735
Change in reserves during 1955		+645,532

* The 1955 production figures were compiled by the committee from records of actual production for whatever period such were available, with estimates for the remainder of the year. Any variance between the actual production, as later reported, and the figures used herein will be compensated for through revision when the following year's reserve report is compiled. These revisions have in the past been very small. Because, in each annual report by this committee, the production figure for the year is an estimate, as just explained, correct total cumulative production cannot be obtained by adding together the figures listed in successive reports of this committee, or in the columns marked "production" of tables 1 and 3.

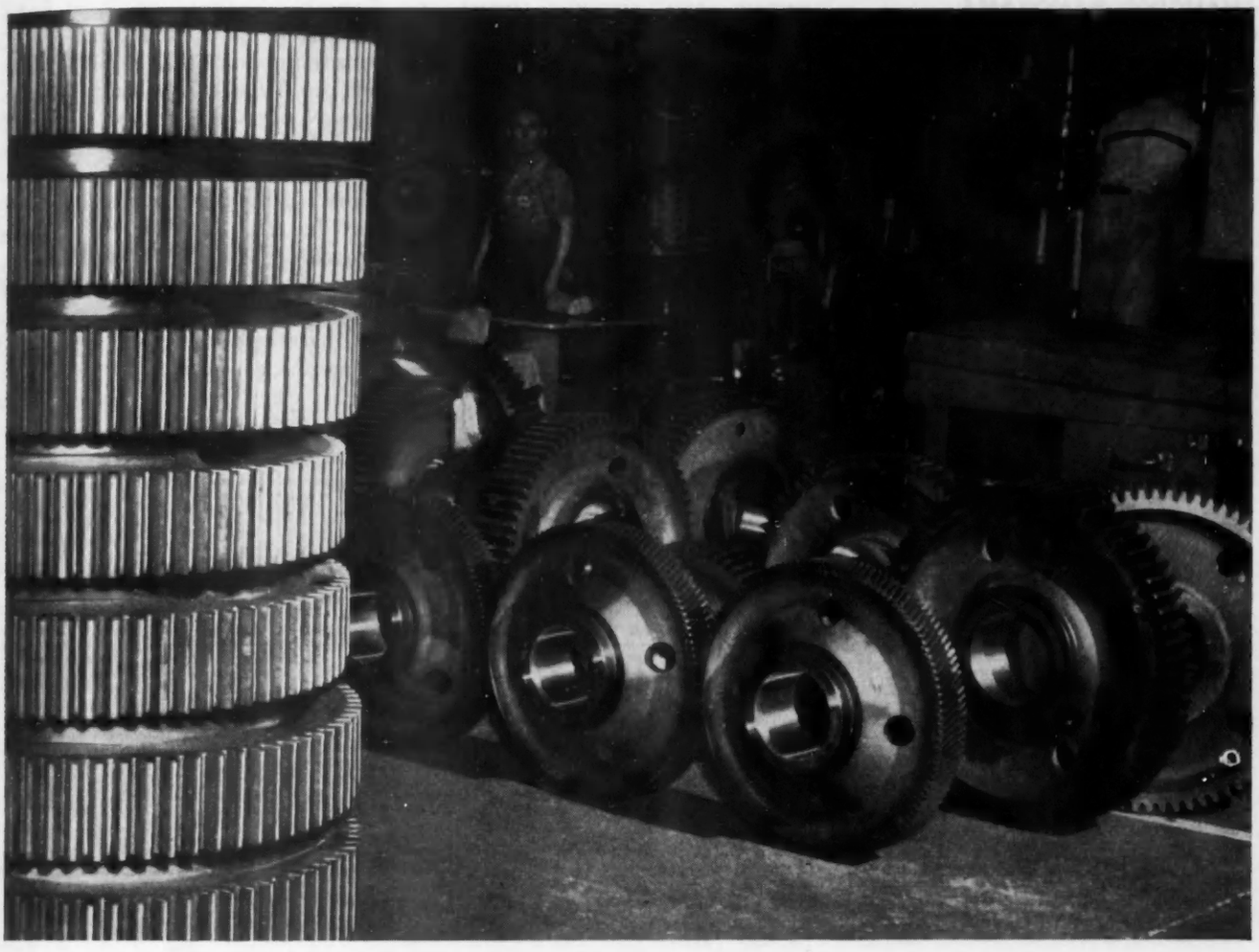
TABLE 3—Estimated Proved Reserves of Liquid Hydrocarbons in U. S. and Canada, by Areas

Sources: For U. S., crude oil from API and natural gas liquids from API and AGA. For Canada, all data via API from Canadian Petroleum Association.

THOUSANDS OF BARRELS

STATE or PROVINCE	Proved Reserves Dec. 31, 1954	Added in 1955 by Extensions and Revisions	[1]Discovered in 1955 in New Fields and New Pools in Old Fields	[2]Production During 1955	Proved Reserves Dec. 31, 1955 (Columns 1 + 2 + 3 Less Column 4)	Changes in Reserves During 1955 (Column 5 Less Column 1)
	(1)	(2)	(3)	(4)	(5)	(6)
UNITED STATES Crude Oil						
Alabama	**15,565**	159	6,300	1,420	**20,604**	+5,039
Arkansas	**351,420**	1,783	2,741	26,405	**329,539**	—21,881
[3]California	**3,888,588**	237,964	29,668	354,812	**3,801,408**	—87,180
Colorado	**328,651**	38,770	19,418	52,836	**334,003**	+5,352
Illinois	**658,411**	110,710	4,395	82,355	**691,161**	+32,750
Indiana	**67,183**	4,651	367	10,743	**61,458**	—5,725
Kansas	**978,449**	123,356	16,737	120,474	**998,068**	+19,619
Kentucky	**85,341**	34,422	3,343	15,652	**107,454**	+22,113
[3]Louisiana	**2,961,651**	381,606	157,125	245,095	**3,255,287**	+293,636
Michigan	**59,620**	10,123	400	11,254	**58,889**	—731
Mississippi	**412,276**	23	11,236	35,833	**387,702**	—24,574
Montana	**272,394**	36,558	5,460	15,464	**298,948**	+26,554
Nebraska	**38,031**	16,540	14,972	11,846	**57,697**	+19,666
New Mexico	**805,886**	86,016	8,576	80,820	**819,658**	+13,772
New York	**45,831**	.....	.....	2,888	**42,943**	—2,888
North Dakota	**134,349**	58,040	4,300	11,157	**185,532**	+51,183
Ohio	**36,772**	23,615	.....	4,387	**56,000**	+19,228
Oklahoma	**1,955,348**	240,932	20,564	200,799	**2,016,045**	+60,697
Pennsylvania	**101,849**	.....	.....	8,505	**93,344**	—8,505
[3]Texas	**14,982,003**	809,657	164,181	1,022,339	**14,933,502**	—48,501
Utah	**36,414**	2,503	356	2,161	**37,112**	+698
West Virginia	**37,312**	12,088	.....	2,400	**47,000**	+9,688
Wyoming	**1,303,577**	162,475	6,548	98,970	**1,373,630**	+70,053
[4]Miscellaneous	**3,825**	1,776	270	685	**5,186**	+1,361
Total U.S.	**29,560,746**	2,393,767	476,957	2,419,300	**30,012,170**	+451,424
[5]Natural Gas Liquids						
[6]Alabama	.....	.....	.....	.....	.....	.....
Arkansas	**46,919**	307	7	2,109	**45,124**	—1,795
[3]California	**330,249**	24,213	1,319	30,840	**324,941**	—5,308
Colorado	**12,747**	446	50	732	**12,511**	—236
Illinois	**22,220**	—1,416	181	2,528	**18,457**	—3,763
Indiana	**151**	3	.....	22	**132**	—19
Kansas	**175,197**	920	2,150	5,031	**173,236**	—1,961
Kentucky	**10,740**	267	133	2,465	**8,675**	—2,065
[3]Louisiana	**884,046**	65,840	24,954	38,890	**935,950**	+51,904
Michigan	**913**	16	25	82	**872**	—41
Mississippi	**60,420**	283	416	3,243	**57,876**	—2,544
Montana	**7,179**	—33	.....	289	**6,857**	—322
Nebraska	**2,268**	4,516	1	349	**6,436**	+4,168
New Mexico	**339,991**	16,264	1,288	15,336	**342,207**	+2,216
Ohio	**1,439**	131	14	27	**1,557**	+118
Oklahoma	**333,911**	43,250	6,558	29,365	**354,354**	+20,443
Pennsylvania	**2,869**	188	94	127	**3,024**	+155
[3]Texas	**2,928,137**	268,695	28,661	180,132	**3,045,361**	+117,224
Utah	**47**	49	17	5	**108**	+61
West Virginia	**33,994**	655	218	4,341	**30,526**	—3,468
Wyoming	**50,686**	2,089	1,260	3,687	**50,348**	—338
[7]Miscellaneous	**334**	20,477	2	800	**20,013**	+19,679
Total U.S.	**5,244,457**	447,160	67,348	320,400	**5,438,565**	+194,108
[8]Total Liquid Hydrocarbons						
[9]Alabama	**15,565**	159	6,300	1,420	**20,604**	+5,039
Arkansas	**398,339**	2,090	2,748	28,514	**374,663**	—23,676
[3]California	**4,218,837**	262,177	30,987	385,652	**4,126,349**	—92,488
Colorado	**341,398**	39,216	19,468	53,568	**346,514**	+5,116
Illinois	**680,631**	109,294	4,576	84,883	**709,618**	+28,987
Indiana	**67,334**	4,654	367	10,765	**61,590**	—5,744
Kansas	**1,153,646**	124,276	18,887	125,505	**1,171,304**	+17,658
Kentucky	**96,081**	34,689	3,476	18,117	**116,129**	+20,048
[3]Louisiana	**3,845,697**	447,446	182,079	283,985	**4,191,237**	+345,540
Michigan	**60,533**	10,139	425	11,336	**59,761**	—772
Mississippi	**472,696**	306	11,652	39,076	**445,578**	—27,118
Montana	**279,573**	36,525	5,460	15,753	**305,805**	+26,232
Nebraska	**40,299**	21,056	14,973	12,195	**64,133**	+23,834
New Mexico	**1,145,877**	102,280	9,864	96,156	**1,161,865**	+15,988
[9]New York	**45,831**	.....	.....	2,888	**42,943**	—2,888
[9]North Dakota	**134,349**	58,040	4,300	11,157	**185,532**	+51,183
Ohio	**38,211**	23,746	14	4,414	**57,557**	+19,346
Oklahoma	**2,289,259**	284,182	27,122	230,164	**2,370,399**	+81,140
Pennsylvania	**104,718**	188	94	8,632	**96,368**	—8,350
[3]Texas	**17,910,140**	1,078,352	192,842	1,202,471	**17,978,863**	+68,723
Utah	**36,461**	2,552	373	2,166	**37,220**	+759
West Virginia	**71,306**	12,743	218	6,741	**77,526**	+6,220
Wyoming	**1,354,263**	164,564	7,808	102,657	**1,423,978**	+69,715
[10]Miscellaneous	**4,159**	22,253	272	1,485	**25,199**	+21,040
Total U.S.	**34,805,203**	2,840,927	544,305	2,739,700	**35,450,735**	+645,532
CANADA Crude Oil						
Northwest Territories	**26,172**	27,939	.....	404	**53,707**	+27,535
Alta. and Br. Col.	**1,928,479**	310,978	41,862	111,334	**2,169,985**	+241,506
Saskatchewan	**222,365**	7,418	18,125	11,036	**236,872**	+14,507
Manitoba	**29,127**	16,743	3,539	4,198	**45,211**	+16,084
Ont.-N. Brunswick	**1,471**	2,783	40	535	**3,759**	+2,288
Total Crude Oil	**2,207,614**	365,861	63,566	127,507	**2,509,534**	+301,920
[11]Natural Gas Liquids	**208,331**	40,404	750	2,400	**247,085**	+38,754
Total Liquid Hydrocarbons	**2,415,945**	406,265	64,316	129,907	**2,756,619**	+340,674

[1] Limited area assigned to a discovery until proved larger. [2] See footnote to Table 2. [3] Includes offshore reserves. [4] Ariz., Fla., Mo., S.D., Tenn., Va. [5] Condensate, natural gasoline, LPG. [6] Incl. in Miscl. [7] Ala., Fla., N.D. [8] Crude oil and natural gas liquids. [9] Crude oil only. [10] Ala. and N.D. natural gas liquids; Ariz., Mo., Nev., S.D., Tenn., and Va. crudes; and Fla. crude and natural gas liquids. [11] All in Alta. and Br. Columbia.



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CHANGING PANORAMA

of natural gas liquids at end of 1955 were estimated at 5,438,565,000 barrels, up 194,108,000 from the end of 1954. New reserves proved up in 1955 totaled 514,508,000 barrels, while production amounted to 320,400,000. The net increase of 194 million barrels contrasted with a decrease of 193 million in 1954. In other postwar years there were net increases ranging from 90 million to 539 million barrels annually. The 514 million barrels proved up in 1955 compared with only 107 million in 1954. In other postwar years, amounts proved up ranged from 252 million to 766 million barrels per year.

Natural Gas. U. S. natural gas reserves increased 12.0 trillion cubic feet in 1955. In other postwar years the annual net increases ranged from a low of ¼ trillion feet in 1954 to a high of 12.8 trillion in 1946. The 22.1 trillion feet of reserves proved up in 1955 was the greatest amount for any year since World War II. In other postwar years, reserves proved up ranged from 9.6 trillion feet in 1954 to 20.5 trillion in 1953.

Canada. Reserves of liquid hydrocarbons in Canada at end of 1955 were estimated at 2,756,619,000 barrels, up 340,674,000 from a year before. New reserves proved up in 1955 totaled 470,581,000 barrels, against production of 129,907,000. In 1954 Canada's reserves increased 372 million barrels, as 469 million were proved up, while 97 million were produced. Present reserves, largely in Western Canada, include 2,509,534,000 barrels of crude and 247,085,000 of natural gas liquids.

—The End

TABLE 4

Summary of Changes in 1955 in Proved U. S. Reserves of Natural Gas

(Source: American Gas Association)

Millions of Cubic Feet—14.65 psia, at 60° F.

Total proved reserves Dec. 31, 1954		211,710,732
Extensions and revisions of previous estimate during 1955	16,298,125	
New reserves discovered in 1955	5,719,069	
Net changes in underground storage during 1955	87,637	
Total proved reserves added and net changes in underground storage during 1955		22,104,831
Total proved reserves Dec. 31, 1954 and additions during 1955		233,815,563
Deduct production during 1955		10,118,118
Total proved reserves Dec. 31, 1955		223,697,445
Increase in reserves during 1955		11,986,713

TABLE 5—Estimated Proved Reserves of Natural Gas in U. S., by Years

Source: AGA . . . Millions of Cubic Feet—14.65 psia, at 60 Deg. F.

Year	NATURAL GAS ADDED DURING YEAR: Extensions and Revisions	Discoveries of New Fields and New Pools in Old Fields	Total of Discoveries Revisions and Extensions	Net Change in Storage	Net Production During Year	Estimated Proved Reserves as of End of Year	Increase Over Previous Year
1945	.....	.....	.....	.....	.....	**147,789,367**	.....
1946	*	*	17,729,152	*	4,942,617	**160,575,901**	12,786,535
1947	7,570,654	3,410,170	10,980,824	*	5,629,811	**165,926,914**	5,351,013
1948	9,769,483	4,129,089	13,898,572	51,482	6,007,628	**173,869,340**	7,942,426
1949	8,061,429	4,612,870	12,674,299	82,746	6,245,041	**180,381,344**	6,512,004
1950	9,172,381	2,877,351	12,049,732	54,301	6,892,678	**185,592,699**	5,211,355
1951	13,013,606	3,039,385	16,052,991	132,751	7,966,941	**193,811,500**	8,218,801
1952	8,934,470	5,411,043	14,345,513	198,850	8,639,638	**199,716,225**	5,904,725
1953	13,371,355	7,081,661	20,453,016	516,431†	9,238,540	**211,447,132**	11,730,907
1954	4,632,309	4,966,894	9,599,203	90,906	9,426,509	**211,710,732**	263,600
1955	16,298,125	5,719,069	22,017,194	87,637	10,118,118	**223,697,445**	11,986,713

* Not Estimated. † All native gas in storage reservoirs formerly classified as a natural gas reserve is included in this figure.

TABLE 6—Estimated Proved Recoverable Reserves of Natural Gas in U. S., by States

Source: AGA . . . Millions of Cubic Feet—14.65 psia, at 60 Deg. F.

STATE	[1]Reserves Dec. 31, 1954	CHANGES IN RESERVES DURING 1955: [1]Extensions and Revisions	[1]Discoveries of New Fields and New Pools in Old Fields	[2]Net Change in Underground Storage	[3]Net Production	[1]RESERVES AS OF DECEMBER 31, 1955: Total (Columns 7+8+9+10 also Columns 1+2+3+4 Less column 5)	[4]Non-Associated	[5]Associated	[6]Dissolved	[7]Underground Storage	Net Change in Reserves in 1955 (Column 6 Less Column 1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Arkansas	**1,165,379**	7,763	30,861	— 1,755	37,881	**1,164,367**	522,670	332,906	303,643	5,148	— **1,012**
[8]California	**9,026,603**	305,096	72,564	2,165	513,478	**8,892,950**	2,209,179	2,093,669	4,535,558	54,544	— **133,653**
Colorado	**1,932,913**	317,290	72,666	0	69,307	**2,253,562**	1,471,797	85,687	696,078	0	+ **320,649**
Illinois	**253,756**	5,306	2,120	662	28,279	**233,565**	7,501	1,000	204,600	20,464	— **20,191**
Indiana	**36,049**	264	0	1,280	4,482	**33,111**	2,402	2,100	21,865	6,744	— **2,938**
Kansas	**15,758,332**	834,214	214,995	1,629	516,090	**16,293,080**	15,687,980	197,016	354,493	53,591	+ **534,748**
Kentucky	**1,286,607**	41,404	8,480	— 1,221	73,000	**1,262,270**	1,184,289	0	57,883	20,098	— **24,337**
[8]Louisiana	**36,799,986**	4,875,622	2,450,107	0	1,690,123	**42,435,592**	33,721,943	5,845,406	2,868,243	0	+ **5,635,606**
Michigan	**330,100**	8,464	5,000	— 7,106	10,584	**325,874**	46,764	18,400	54,613	206,097	— **4,226**
Mississippi	**2,772,683**	25,340	20,945	130	210,758	**2,608,340**	1,835,169	479,619	292,610	942	— **164,343**
Montana	**723,731**	11,401	17,048	57	32,518	**719,719**	563,626	40,066	85,684	30,343	— **4,012**
Nebraska	**192,946**	24,802	5,200	0	19,527	**203,421**	105,882	15,049	82,490	0	+ **10,475**
New Mexico	**17,240,669**	1,620,564	254,287	13,567	544,175	**18,584,912**	15,218,048	1,635,380	1,646,840	84,644	+ **1,344,243**
New York	**69,362**	— 2,514	1,000	11,064	3,152	**75,760**	34,354	0	345	41,061	+ **6,398**
N. Dakota	**164,025**	130,188	3,077	0	16,594	**280,696**	6,689	0	274,007	0	+ **116,671**
Ohio	**774,741**	46,601	7,952	15,661	35,081	**809,874**	518,456	0	37,222	254,196	+ **35,133**
Oklahoma	**12,396,148**	1,388,178	293,842	5,269	878,698	**13,204,739**	6,513,510	2,909,723	3,694,555	86,951	+ **808,591**
Pennsylvania	**732,163**	43,529	67,048	35,253	123,604	**754,389**	427,175	0	34,029	293,185	+ **22,226**
[8]Texas	**105,129,062**	6,164,388	1,974,608	1,511	4,982,021	**108,287,548**	67,744,032	24,815,726	15,712,978	14,812	+ **3,158,486**
Utah	**387,375**	1,912	49,870	0	18,261	**420,896**	418,599	1,636	661	0	+ **33,521**
W. Virginia	**1,607,290**	91,634	39,725	9,989	183,739	**1,564,899**	1,332,676	0	56,116	176,107	— **42,391**
Wyoming	**2,855,071**	351,472	112,546	— 1,438	121,548	**3,196,103**	2,416,351	197,816	563,518	18,418	+ **341,032**
[9]Miscel.	**75,741**	5,207	15,128	920	5,218	**91,778**	66,071	0	24,787	920	+ **16,037**
Total	**211,710,732**	16,298,125	5,719,069	87,637	10,118,118	**223,697,445**	152,055,163	38,671,199	31,602,818	1,368,265	+ **11,986,713**

[1] Excludes gas loss due to natural gas liquids recovery. [2] The net difference between gas stored in and gas withdrawn from underground storage reservoirs, inclusive of adjustments and native gas transferred from other reserve categories. [3] Net production equals gross withdrawals less gas injected into producing reservoirs. Changes in underground storage and gas loss due to natural gas liquids recovery are excluded. Fourth quarter production estimated in some instances. [4] Non-associated gas is free gas not in contact with crude oil in the reservoirs. [5] Associated gas is free gas in contact with crude oil in the reservoirs. [6] Dissolved gas is gas in solution with crude oil in the reservoirs. [7] Gas held in underground reservoirs (including native and net injected gas) for storage purposes. [8] Includes off-shore reserves. [9] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri, Nevada, and Virginia.

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By Ray L. DUDLEY, Publisher, and WARREN L. BAKER, Editor

Market Trend Depends on Refining Rates

Good conditions will exist if runs to stills are reduced during the next two months. Excessive stocks will cause trouble if runs remain at high levels.

THE NEXT TWO MONTHS will be a very critical period for the U. S. oil industry. Demand for petroleum products in April and May will decline sharply from recent winter volumes, perhaps as much as 1 million barrels per day. Therefore, operating levels during this time will determine whether the industry's markets are to remain strong and stable or be weakened by surplus supplies.

Higher consuming rates than a year ago will help the industry, but operating levels must be curtailed from recent peak volumes if surplus supplies are to be avoided.

At the moment, the outlook is uncertain. Conditions ahead can be good or they can be bad. Everything depends on operating levels in coming months. Due to high gasoline inventories, there is a particularly strong need for reduced crude runs to stills.

•

KEY TO THE SITUATION is the level of refining operations during the next 60 days. They must be at more moderate volumes than during the early part of the year, if excessive gasoline supplies are not to be created.

Highly encouraging is the recent indication that U. S. refiners may curtail crude runs. Crude runs to stills averaged slightly over 8 million barrels daily during January and February, then rose to a peak of 8,093,000 barrels during the week ended March 2. However, they declined slightly during the week ended March 9. This was followed by a significant decrease during the week ended March 16, when they averaged only 6,986,000 barrels daily or 1 million below January and February.

If this recent reduction in refinery runs is maintained in the days ahead, everything will be fine. Announcements by several refiners that they will reduce runs is significant, creating hope sufficient reductions will take place to permit the industry to avoid surplus inventories despite lower consumption during April and May.

•

THE MOST CRITICAL QUESTION is that of gasoline supplies. High refining levels during the first 2 months of this year resulted in gasoline inventories advancing to an all-time peak. Motor fuel stocks totaled 196 million barrels on March 16.

At this level they were 12 million barrels larger than a year ago. This represented a slight improvement over a month ago, when they had been 12½ million barrels greater than 12 months before. However, two months ago motor fuel stocks were only 9½ million barrels greater than at the corresponding period of the year previous.

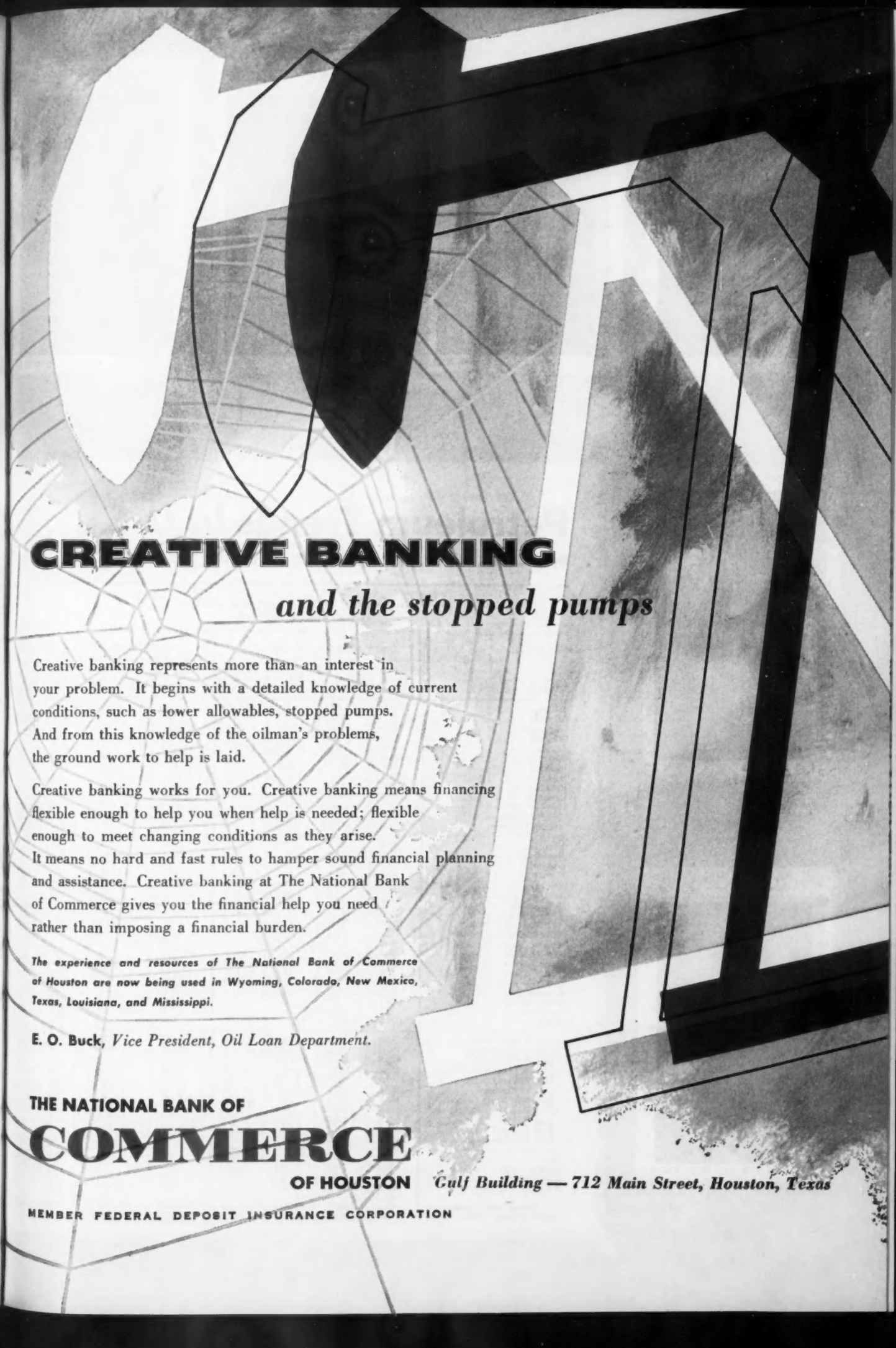
Any further expansion of this margin of growth would be highly detrimental to future markets. Surplus gasoline supplies would plague the industry's markets for months to come. Before the situation could be corrected, refinery runs would have to be curtailed drastically over a period of time. This would decrease the demand for crude oil production.

The future trend in gasoline inventories depends on refinery runs. Until the industry has a chance to see how demand is running, it would be wise for refinery runs to be held to around 7¼ and 7⅓ million barrels per day. This would compare with 7,136,000 barrels during the month of April, 1955.

•

THERE ALSO IS A NEED for curtailment of U. S. crude producing rates and import volumes. High refining levels have permitted record domestic crude production and imports. But if refinery runs are curtailed to meet lower demand in April and May, it would be helpful if the supply of crude also is reduced.

U. S. crude stocks on March 10 totaled 256 million barrels, 4½ million less than a year ago. However, continued high production and import rates would boost inventories levels if refinery runs are curtailed. It would be well for crude production and imports to be tailored to fit lower demand volumes during the next two months.



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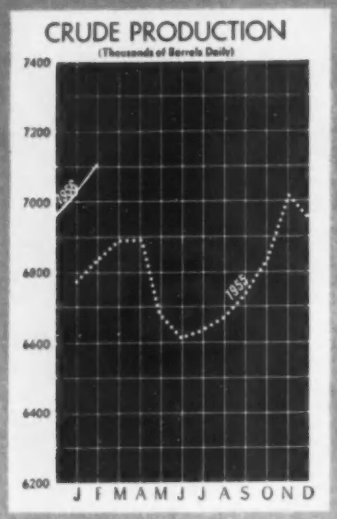
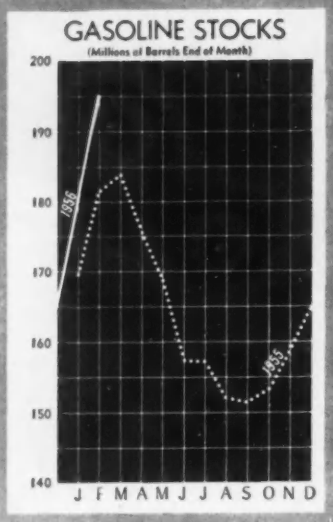
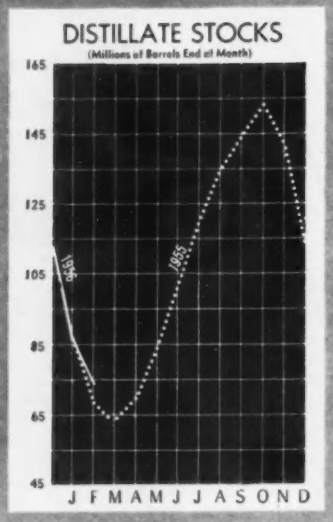
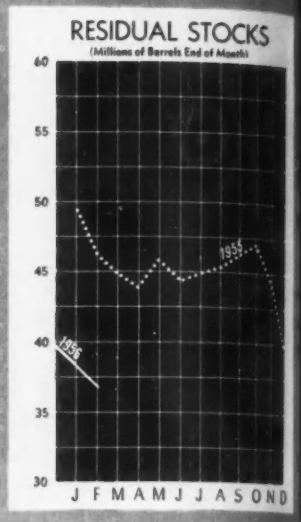
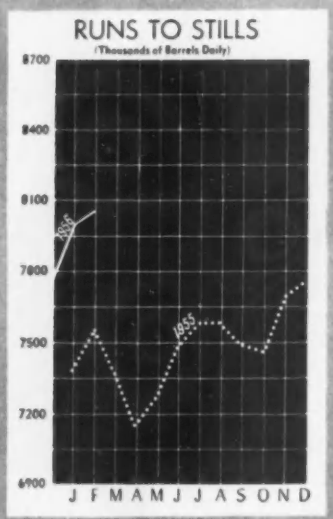
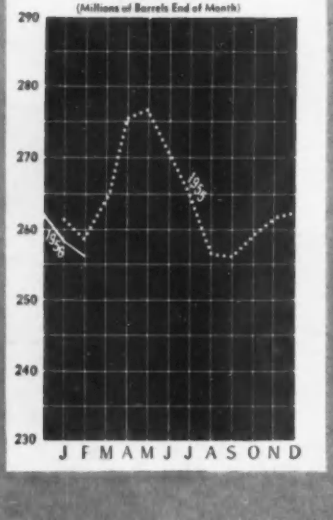












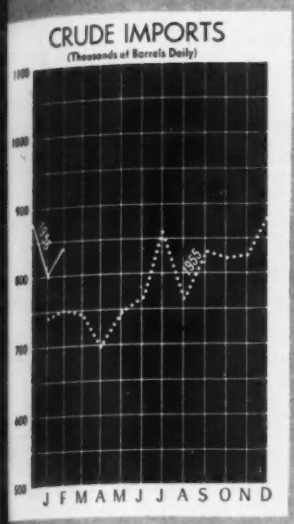
Petroleum Trends In U. S. . . .

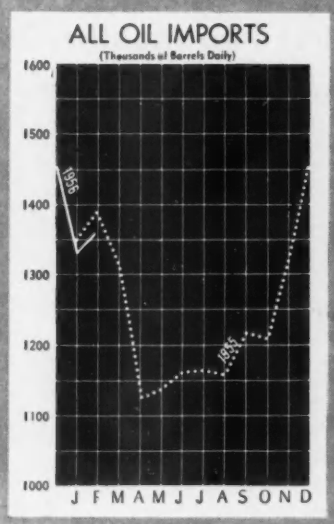
By CECIL W. SMITH, World Oil Staff

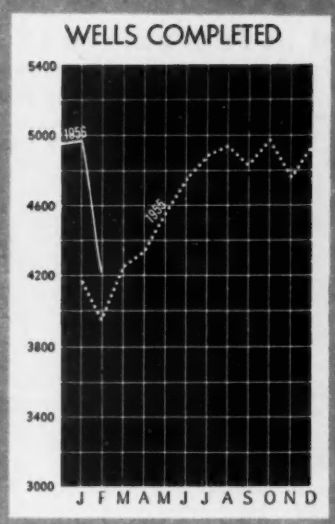
U. S. Crude Production by States

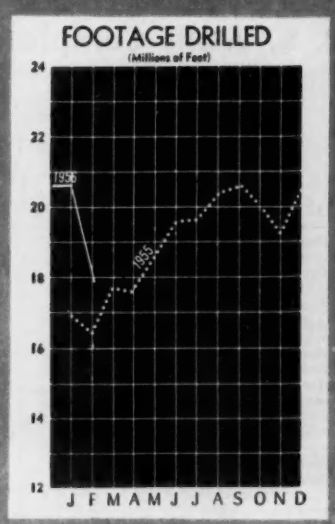
(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION Feb., 1956	Jan., 1956	Feb., 1955	% Diff. Feb., '56-'55	TOTAL PRODUCTION First Two Months 1956	1955	% Diff. '56-'55
Alabama	4.3	4.2	4.1	+ 4.9	255	247	+ 3.2
Arkansas	73.6	73.4	77.5	— 5.0	4,408	4,537	— 2.9
California	972.6	979.1	967.6	+ 0.5	58,556	56,971	+ 2.8
Colorado	159.4	158.6	120.9	+ 31.8	9,538	7,153	+ 33.3
Florida	1.4	1.4	1.2	+ 16.7	82	76	+ 7.9
Illinois	228.8	231.9	214.9	+ 6.5	13,825	12,413	+ 11.4
Indiana	31.4	30.8	28.7	+ 9.4	1,868	1,715	+ 8.9
Kansas	332.5	336.8	341.7	— 2.7	20,085	20,128	— 0.2
Kentucky	45.4	44.7	38.4	+ 18.2	2,703	2,264	+ 19.4
Louisiana	802.6	789.3	713.1	+ 12.6	47,745	41,671	+ 14.6
North Louisiana	119.9	117.7	117.9	+ 1.7	7,127	6,927	+ 2.9
South Louisiana	682.7	671.6	595.2	+ 14.7	40,618	34,744	+ 16.9
Michigan	30.2	30.2	32.7	— 7.7	1,815	1,893	— 4.1
Mississippi	111.4	111.4	95.8	+ 16.3	6,684	5,518	+ 21.1
Missouri	0.2	0.2	0.2	.....	10	10	.....
Montana	50.5	49.4	43.5	+ 16.1	2,997	2,588	+ 15.8
Nebraska	29.2	28.8	21.8	+ 33.9	1,737	1,324	+ 31.2
Nevada	0.3	0.3	0.2	+ 50.0	16	10	+ 60.0
New Mexico	235.8	229.9	222.5	+ 6.0	13,965	13,026	+ 5.7
Southeast New Mexico	234.1	228.3	219.8	+ 6.5	13,868	12,859	+ 7.8
Northwest New Mexico	1.7	1.6	2.7	— 37.0	98	167	— 41.3
New York	10.2	10.1	8.2	+ 24.4	607	470	+ 29.1
North Dakota	34.4	41.3	32.5	+ 5.8	2,279	1,845	+ 23.5
Ohio	12.5	12.8	10.6	+ 17.9	759	615	+ 23.4
Oklahoma	608.5	599.6	561.0	+ 8.5	36,232	31,947	+ 13.4
Pennsylvania	19.3	19.4	21.7	— 11.1	1,162	1,266	— 8.2
South Dakota	0.1	0.1	0.1	.....	3	5	— 40.0
Tennessee	0.1	0.1	0.1	.....	2	3	— 33.3
Texas	3,026.4	2,943.7	2,997.6	+ 1.0	179,019	176,886	+ 1.2
Dist. 1: South Central	53.2	48.8	49.5	+ 7.5	3,057	2,834	+ 7.9
Dist. 2: Middle Gulf	159.8	161.5	157.5	+ 1.5	9,639	9,288	+ 3.8
Dist. 3: Upper Gulf	465.8	454.8	473.6	— 1.7	27,610	27,861	— 0.9
Dist. 4: Lower Gulf-S.W.	251.4	247.7	258.2	— 2.6	14,968	15,223	— 1.7
Dist. 5: East Central	47.0	46.6	48.6	— 3.3	2,806	2,940	— 4.6
Dist. 6: Northeast	359.1	356.7	366.3	— 2.0	21,471	21,699	— 1.1
Dist. 7-B: North Central	156.0	150.4	140.4	+ 11.1	9,187	8,295	+ 10.8
Dist. 7-C: West Central	182.8	174.0	187.8	— 2.7	10,697	10,959	— 2.4
Dist. 8: West	1,049.4	1,013.9	970.6	+ 8.1	61,862	56,968	+ 8.6
Dist. 9: North	208.7	197.1	193.8	+ 7.7	12,163	11,310	+ 7.5
Dist. 10: Panhandle	93.2	92.2	86.1	+ 8.2	5,559	5,049	+ 10.1
Utah	6.6	6.1	5.7	+ 15.8	381	323	+ 18.0
Virginia	0.1	0.1	0.1	.....	2	2	.....
West Virginia	6.3	5.9	6.4	— 1.6	366	376	— 2.7
Wyoming	283.2	288.3	266.8	+ 6.1	17,151	15,710	+ 9.2
Total United States	7,117.1	7,027.9	6,835.6	+ 4.1	424,252	400,992	+ 5.8









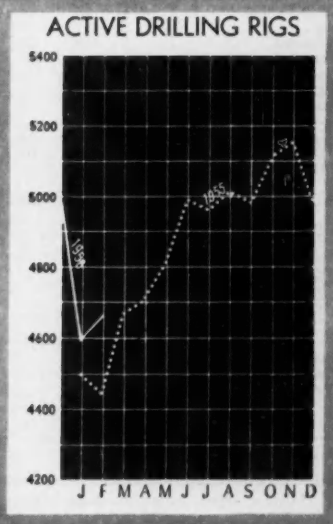
- **Crude production near peak volume**
- **Drilling continues at record rate**
- **Refinery thruput at highest level**

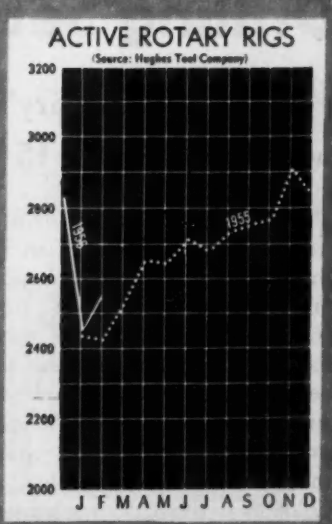
Crude Oil and Refined Products Trends

(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1954:											
January	6,240	6,947	270,811	3,431	171,704	1,550	81,044	1,271	47,474	617	1,143
February	6,379	7,068	266,918	3,476	179,950	1,545	70,390	1,241	47,119	621	1,144
March	6,507	6,923	271,867	3,375	181,297	1,458	60,270	1,168	44,249	654	1,088
April	6,615	6,811	280,310	3,404	177,006	1,374	61,721	1,140	44,362	574	950
May	6,471	7,038	282,250	3,482	177,606	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	1,399	86,325	1,123	50,216	624	999
July	6,242	6,916	284,894	3,480	158,010	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	1,453	117,579	1,069	56,322	664	966
September	6,151	6,939	274,608	3,511	150,916	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	1,545	139,128	1,066	56,541	642	1,065
November	6,346	6,975	264,566	3,530	150,604	1,622	133,886	1,120	54,891	636	1,104
December	6,394	7,238	258,385	3,605	155,400	1,668	108,144	1,187	52,105	729	1,301
1955:											
January	6,761	7,379	260,156	3,639	169,562	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	1,534	70,139	1,110	43,838	697	1,123
May	6,677	7,281	276,948	3,605	168,751	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	1,621	143,248	1,061	46,267	829	1,218
October	6,831	7,465	267,346	3,827	153,103	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	1,765	111,333	1,286	39,174	884	1,502
1956:											
January	7,028	8,003	258,322	3,810	181,066	1,927	86,343	1,300	38,476	797	1,330
February	7,117	8,045	256,964	3,726	194,474	1,939	72,414	1,285	36,388	842	1,364
Feb. 1956 Change:											
In Month	+89	+42	+1,358	−84	+13,408	+12	−13,929	−15	−2,088	+45	+34
In Year	+282	+454	−1,666	+71	+12,831	+92	+3,901	+46	−9,654	+91	−15
Week Ended:											
2-16-56	7,153	7,986	256,666	3,722	195,941	1,844	67,744	1,292	35,038	1,008	1,399
3-18-55	6,858	7,474	261,719	3,492	183,840	1,696	63,735	1,220	44,801	830	1,395

Source: Data for last two months from API; prior monthly data from Bureau of Mines.





U. S. Wells Completed in February and First Two Months, 1956-1955

STATE or DISTRICT	NEW WELLS COMPLETED AND FOOTAGE DRILLED — DETAILS FOR FEBRUARY: Oil	Dist.	Gas	Dry	Water Input	Gas Input	Water Disposal	TOTAL NEW WELLS: Feb., 1956	Jan., 1956	Feb., 1955	Total Footage February, 1956	DETAILS FOR JANUARY-FEBRUARY: NEW WELLS: 1956	1955	Percent Diff.	FOOTAGE: 1956	1955	Rigs in Operation: Feb. 29, 1956	Jan. 31, 1956	Feb. 28, 1955
Alabama	1			4				5	7	8	39,931	12	14	— 14.3	97,352	57,148	10	10	6
Arizona													4	—100.0		16,136			
Arkansas	24		1	23				48	69	41	157,082	117	83	+ 41.0	372,883	289,819	57	50	29
California	128		3	40				171	202	175	839,836	373	339	+ 10.0	1,799,810	1,681,826	211	192	265
Colorado	21		7	73				101	133	107	538,395	234	216	+ 8.3	1,247,850	1,153,737	59	64	70
Florida				4				4	1	3	18,682	5	9	— 44.5	28,170	60,237			3
Georgia																	2	3	
Idaho										1			1	—100.0		4,530			
Illinois	93		3	93				191	317	240	463,300	508	543	— 6.5	1,211,133	1,327,142	187	250	242
Indiana	9			20				29	64	36	51,496	93	80	+ 16.3	158,273	126,132	69	84	94
Kansas	155		27	169			3	354	350	343	1,299,516	704	665	+ 5.9	2,562,166	2,435,805	435	422	470
Kentucky	42		17	46	1			106	170	125	151,457	276	232	+ 19.0	387,932	383,568	132	124	78
Louisiana	149	19	26	85				279	245	293	2,288,777	524	644	— 18.6	4,250,280	3,812,105	396	372	315
North Louisiana	53		11	27				91	71	158	360,457	162	356	— 54.5	623,660	991,754	72	59	69
South Louisiana	96	19	15	58				188	174	135	1,928,320	362	288	+ 25.7	3,626,620	2,820,351	324	313	246
* Gulf of Mexico	26		4	9				39	32	17	350,093	71	46	+ 54.3	628,210	421,670	67	61	35
Maryland																	2	2	2
Michigan	19			18				37	54	41	112,893	91	97	— 6.2	259,634	288,421	71	65	88
Mississippi	14		2	18				34	39	46	246,062	73	77	— 5.2	535,446	603,962	36	37	46
Missouri									1	3		1	8	— 87.5	1,960	5,494	2	1	2
Montana	16		2	7				25	51	32	132,731	76	60	+ 26.7	370,275	294,891	38	35	31
Nebraska	30			56				86	75	53	471,765	161	96	+ 67.7	885,438	536,738	40	42	40
Nevada									1	2		1	3	— 66.7	7,885	22,416	3	4	2
New Mexico	73		43	30				146	151	102	713,274	297	193	+ 53.9	1,441,623	854,760	154	147	132
New York	16				10			26	23	25	36,100	49	51	— 3.9	71,900	70,861	40	41	40
North Dakota	18			9				27	21	13	213,162	48	29	+ 65.5	370,329	211,072	21	20	23
Ohio	45		7	29				81	98	69	208,639	179	159	+ 12.6	431,108	342,055	212	214	195
Oklahoma	340	13	19	149	12		8	541	831	418	1,965,653	1,372	971	+ 41.3	5,007,143	3,437,338	640	669	638
Oregon																			1
Pennsylvania	19		37	16	18	1		91	97	58	242,3387	188	116	+ 62.1	494,461	214,948	134	121	104
South Dakota				1				1			9,361	1	2	— 50.0	9,361	6,752	1	2	2
Texas	1,018	34	61	582	23		1	1,719	1,889	1,593	7,177,697	3,608	3,156	+ 14.3	15,279,486	13,672,656	1,467	1,367	1,313
Dist. 1: South Central	81		3	62				146	173	129	432,441	319	266	+ 19.9	854,607	727,509	48	47	52
Dist. 2: Middle Gulf	18	10	5	25				58	89	67	349,874	147	130	+ 13.1	919,103	791,818	50	41	29
Dist. 3: Upper Gulf	57	13	8	62				140	138	133	940,948	278	276	+ 0.7	1,842,683	1,782,708	151	133	116
* Gulf of Mexico			1	2				3			32,075	3			32,075		4	3	3
4: Lower Gulf-S.W.	37	10	13	59				119	107	115	666,212	226	227	— 0.5	1,238,735	1,234,490	82	84	70
* Gulf of Mexico									3	1		3	3		31,176	27,820	2	1	3
Dist. 5: East Central			1	8				9	33	27	29,617	42	51	— 17.7	140,534	224,200	16	16	14
Dist. 6: Northeast	36	1	7	20				64	86	57	335,151	150	100	+ 50.0	781,655	562,406	67	57	61
Dist. 7-B: North Central	107		3	97	4			211	356	240	643,873	567	517	+ 9.7	1,876,292	1,538,980	155	153	148
Dist. 7-C: West Central	86		2	18				106	90	99	531,545	196	207	— 5.3	947,525	1,125,030	135	113	135
Dist. 8: West	277		3	41				321	292	270	1,636,760	613	548	+ 11.8	3,125,509	3,013,911	413	398	380
Dist. 9: North	254		7	181	19		1	462	399	365	1,313,589	861	666	+ 29.3	2,774,833	2,108,659	255	230	233
Dist. 10: Panhandle	65		9	9				83	126	82	297,687	209	168	+ 24.4	778,010	562,945	95	101	75
Utah	1		1	5				7	22	11	44,302	29	20	+ 45.0	146,689	105,880	19	15	14
West Virginia	7		34	8				49	78	41	132,489	127	104	+ 22.1	334,264	281,324	175	172	175
Wyoming	34		5	21				60	110	66	317,221	170	135	+ 25.9	862,762	707,120	64	72	56
Total United States	2,274	66	295	1,506	64	1	13	4,218	5,099	3,945	17,872,158	9,317	8,107	+ 14.9	38,625,613	33,004,873	4,677	4,597	4,456
Total Western Canada	142		3	50			1	196	259	259	910,216	455	442	+ 2.9	2,137,982	1,923,107	233	211	199

* Gulf of Mexico wells are included in their respective district totals.

Drilling Sets Fast Pace

February's wells take seasonal drop, but year's wells lead 1955 by 15 percent.

THE U. S. INDUSTRY drilled fewer wells during February than it did in the previous month, but it was a normal seasonal trend. This came partly from the shortness of the month, but more important from the weather's depressing influence. However, February's completed wells topped those recorded a year earlier, and helped maintain the substantial lead this year holds over the 1955 record.

A total of 4218 new wells were completed during the month, to best the 3945 finished in February of last year. However, they fell short of January's 5099, and the fewer number of days in the month was not the whole answer. February's rate was 145 new wells per day, while 164 wells were averaged during January.

Despite the slackening, this year's completed wells, totaling 9317, still holds a lead of 14.9 percent over the 8107 drilled in the comparable period of 1955. Last year proved to be the most active drilling year in the industry's history, and with this year's wells currently holding such a wide margin, indications are that the drilling peak expected in 1956 is off to a good running start.

A better measure of the year's drilling operations is a comparison of the footage drilled with last year's. In two months, a total of 38,625,613 feet was drilled, which was an increase of 17 percent over the 33,004,873 feet represented in 1955's wells. Twenty years ago this amount of footage drilled would have represented almost six months work by the nation's drillers.

Today, wells are averaging 4146 feet each in depth, while a year ago the per well average had been 4071 feet, and the average is continuing to increase. This is partly due simply to deeper drilling in many areas, but a great part also is due to the increase in activity in areas where deep drilling is not new, and a decreased, or settled, rate in the old shallow areas.

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Wildcat Drilling—in February and First Two Months, 1956-1955

STATE or DISTRICT	MONTH OF FEBRUARY, 1956						FIRST TWO MONTHS, 1956-1955								
	New Fields			Total Discoveries	Dry Wildcats	Total Wildcat Tests	New Fields			Total Discoveries		Dry Wildcats		Total Wildcat Tests	
	Oil	Distillate	Gas				Oil	Distillate	Gas	2 Mo. 1956	2 Mo. 1955	2 Mo. 1956	2 Mo. 1955	2 Mo. 1956	2 Mo. 1955
Alabama	....	....	....	....	2	2	....	....	....	....	....	3	14	3	14
Arizona	....	....	....	....	....	....	....	....	....	....	....	....	4	....	4
Arkansas	....	....	1	1	10	11	1	....	2	3	2	22	21	25	23
California	....	....	....	....	1	1	....	....	1	1	2	9	39	10	41
Colorado	1	....	....	1	37	38	4	....	2	6	12	98	113	104	125
Florida	....	....	....	....	4	4	....	....	....	....	....	5	8	5	8
Idaho	....	....	....	....	....	....	....	....	....	....	....	....	1	....	1
Illinois	1	....	....	1	41	42	2	....	....	2	2	110	98	112	100
Indiana	....	....	....	....	6	6	1	....	....	1	5	21	18	22	23
Kansas	14	....	....	14	73	87	24	....	4	28	31	137	124	165	155
Kentucky	....	....	....	....	6	6	....	....	....	....	3	21	12	21	15
Louisiana	1	1	2	4	40	44	3	4	2	9	4	70	65	79	69
North Louisiana	....	....	....	....	15	15	....	....	....	....	....	20	29	20	29
South Louisiana	1	1	2	4	25	29	3	4	2	9	4	50	36	59	40
Michigan	1	....	....	1	13	14	2	....	....	2	1	27	42	29	43
Mississippi	....	....	....	....	12	12	....	1	....	1	2	29	31	30	33
Missouri	....	....	....	....	....	....	....	....	....	....	....	1	8	1	8
Montana	2	....	1	3	4	7	3	....	1	4	1	23	22	27	23
Nebraska	3	....	....	3	37	40	6	....	....	6	8	71	43	77	51
Nevada	....	....	....	....	....	....	....	....	....	....	....	....	3	....	3
New Mexico	2	....	1	3	11	14	4	....	1	5	10	27	17	32	27
North Dakota	3	....	....	3	6	9	3	....	....	3	....	11	5	14	5
Ohio	....	....	....	....	....	....	....	....	....	....	1	....	4	....	5
Oklahoma	7	1	....	8	43	51	13	2	4	19	17	122	72	141	89
South Dakota	....	....	....	....	1	1	....	....	....	....	....	1	2	1	2
Texas	47	5	7	59	340	399	88	8	15	111	113	776	705	887	818
Dist. 1: South Central	3	....	3	6	42	48	5	....	3	8	5	94	64	102	69
Dist. 2: Middle Gulf	1	1	....	2	13	15	3	1	1	5	10	30	37	35	47
Dist. 3: Upper Gulf	4	3	2	9	39	48	6	5	2	13	7	72	67	85	74
Dist. 4: Lower Gulf-S.W.	....	....	....	....	40	40	2	....	3	5	6	70	72	75	78
Dist. 5: East Central	....	....	....	....	4	4	....	....	....	....	2	23	20	23	22
Dist. 6: Northeast	1	1	1	3	13	16	2	1	1	4	....	40	27	44	27
Dist. 7-B: North Central	11	....	....	11	62	73	22	....	1	23	34	174	149	197	183
Dist. 7-C: West Central	6	....	....	6	12	18	10	....	1	11	9	36	45	47	54
Dist. 8: West	13	....	....	13	28	41	21	....	....	21	10	70	73	91	83
Dist. 9: North	6	....	1	7	82	89	13	....	1	14	30	154	147	168	177
Dist. 10: Panhandle	2	....	....	2	5	7	4	1	2	7	....	13	4	20	4
Utah	1	....	1	2	5	7	1	....	1	2	3	21	13	23	16
West Virginia	....	....	....	....	....	....	....	....	....	....	2	....	3	....	5
Wyoming	....	....	....	....	15	15	1	....	1	2	6	59	30	61	36
Total United States	83	7	13	103	707	810	156	15	34	205	225	1,664	1,517	1,869	1,742

Wildcatting Activity Continues at Fast Clip

February's tests take customary dip, but year's lead holds at 7 percent.

WILDCAT DRILLING declined during February as is customary each year. But this activity remained relatively high, and as a result wildcat wells completed in the first two months of this year topped last year's record by 7.3 percent. The fact that 1955 was the most active wildcat drilling period in history, indicates that this year's program is off to a good start towards the new peak expected.

Despite the greater number of tests completed so far, the 1956 campaign cannot boast of bettering last year's results. In fact, discoveries this year have lagged almost 9 percent behind those made in the first two months of 1955.

February's 103 new discoveries amounted to 12.7 percent of the 810 new wildcats completed. That boosted the year's discoveries to 205, and they amounted to 11 percent of the 1869 total drilled. Last year, by the same time, new finds had totaled 225, which figured to be 12.9 percent of the 1742 tests drilled. That means that the producer-to-dry hole ratio has dropped 1.9 percent this year.

The month's discoveries were made up of 83 new oil fields, 13 new gas fields, and 9 gas-distillate areas. In comparison, discoveries made in last year's comparable period totaled exactly the same. However, breakdown differed slightly, being 80 new oil fields, 16 gas areas, and 7 gas-distillate fields.

The first two months saw 156 new oil fields opened, but they fell short of the 174 found a year earlier. Thirty-four new gas fields this year also failed to match last year's 38. Only type of discovery that has kept pace has been the gas-distillate finds, and they totaled 15 to last year's 13.

Texas, the leading wildcat state, was the site of 69 more tests this year than a year ago, but the results were two fewer discoveries. The second-ranking state was Kansas, where ten more wildcat completions resulted in three less strikes.

Summary of Results of Wildcat Drilling

ITEM	Feb., 1956	Jan., 1956	TWO MONTHS January-February 1956	1955	Percent Diff.
New Field Discoveries					
Oil	83	73	156	174	— 10.4
Distillate	7	8	15	13	+ 15.4
Gas	13	21	34	38	— 10.5
Total Discoveries	103	102	205	225	— 8.9
Dry Wildcats	707	957	1664	1517	+ 9.7
Total Wildcats	810	1059	1869	1742	+ 7.3
Percent Productive	12.7	9.6	11.0	12.9	.....
Percent Dry	87.3	90.4	89.0	87.1	.....

Mississippi Structure Shows Promise of Vast Reserves

Does the Ansley field tie in with the Citronelle area? And just what promise does the Heterostegina section hold from the standpoint of commercial production? The answer to these questions will spell either fabulous or mediocre success for Mississippi operators.

By WILLIS HUGHES
Independent Operator, Jackson, Mississippi

THE PROSPECT of uncovering large commercial reserves in Mississippi has been strengthened by the opening of the Ansley Field in Hancock County, not far from the Louisiana border. The discovery well is the Cuevas 1, drilled by Marshall R. Young of Fort Worth along with the Union Producing Company. The well tested 264 barrels of 41.8 gravity oil and 2.5 million cubic feet of gas per day through a one-quarter inch choke. Production originates from the Washita-Fredericksburg horizon of the lower Cretaceous.

Much of the original data leading to this discovery was uncovered by Sun Oil Company who drilled eight dry holes since 1948. Another dry hole is credited to Young while the author drilled one deep and two shallow dry holes.

Two other possibilities in the area offer operators certain encouragement. One being the presence of oil in the Heterostegina and the other the possibility that the deeper Citronelle pay zone may be present in the Ansley field. Existing production in the state is many miles from the Ansley field. The nearest producing fields are Maxie, Baxterville and Pistol Ridge.

RECENT PLEISTOCENE		
MIOCENE	Flemming - Anahuac - Heterostegina (Frio) Chickasawhay	
OLIGOCENE	Vicksburg	Byram Mariana Forest Hill
EOCENE	Jackson	Yazoo Clay Moodys Branen
	Claiborne	Cockfield Cook Mt. Sparta Winnona Tallahatta
	Wilcox	Wilcox Unidiff
	Midway	Midway Unidiff
Upper Cretaceous	Selma Chalk Eutaw Eagle Ford Upper Tuscaloosa Marine " Lower "	
Lower Cretaceous	Dantzler Formation Washita Fredericksburg Paluxy Formation Morningsport F M Ferry Lake Anhydrite Rodessa Lower Trinity Hosston	

FIGURE 1—Correlation chart of southern Mississippi.

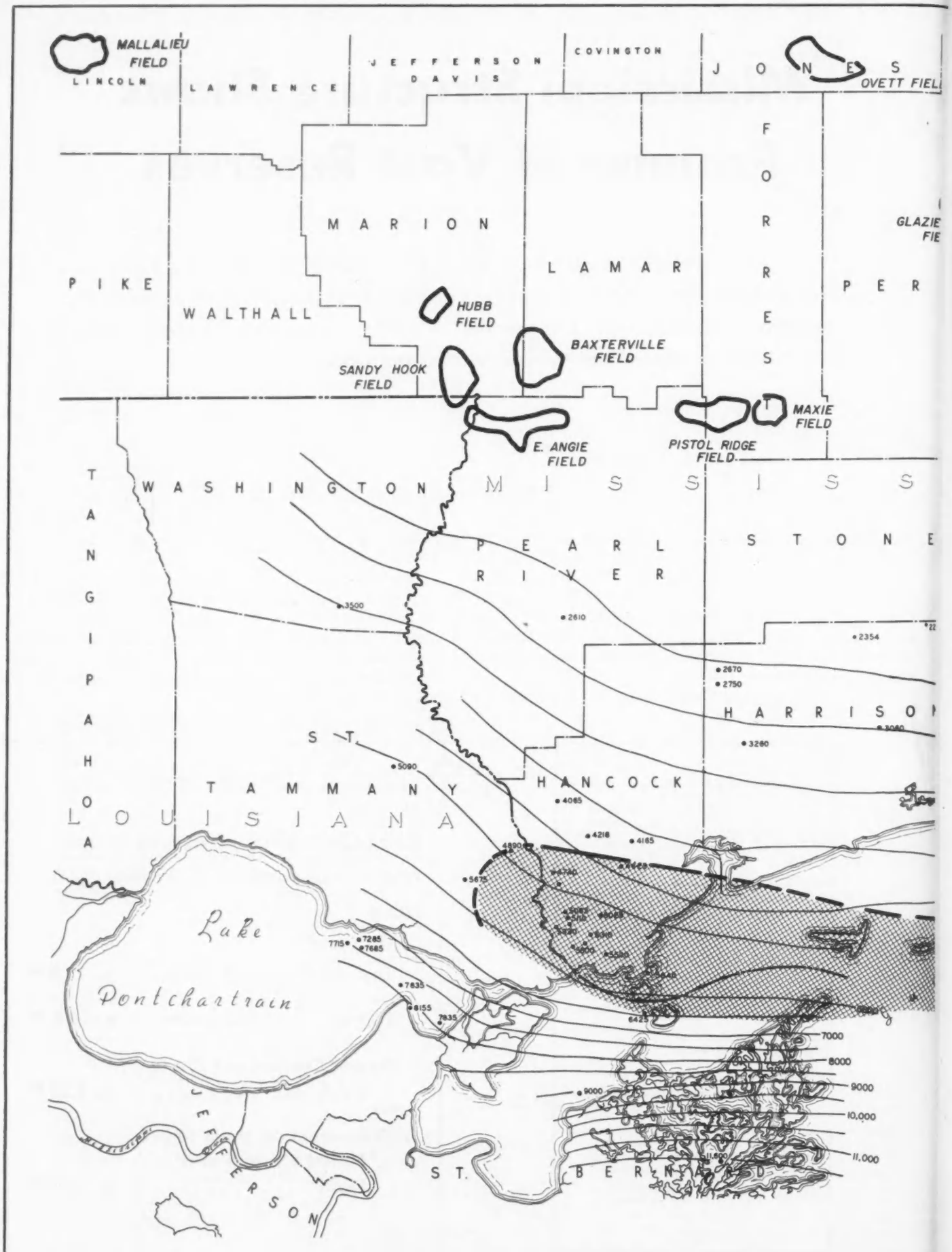
Keep going for structure maps and cross-section of Mississippi area . . .

Top of Heterostegina . . . . p. 116 ►

Top of Lower Tuscaloosa . . p. 118 ►

Upper Cretaceous Chalk Thickness . . . . . p. 120 ►

Cross-section from Maxie Field to Shell Point Field . . . . . p. 122 ►


MALLALIEU FIELD
LINCOLN
LAWRENCE
JEFFERSON DAVIS
COVINGTON
JONES
OVETT FIEL
FORREST
MARION
LAMAR
PIKE
WALTHALL
HUBB FIELD
BAXTERVILLE FIELD
SANDY HOOK FIELD
MAXIE FIELD
E. ANGIE FIELD
PISTOL RIDGE FIELD
WASHINGTON
PEARL RIVER
STONE
TANGIPAHOA
ST. TAMMANY
HANCOCK
LOUISIANA
HARRISON
Lake Pontchartrain
JEFFERSON
ST. BERNARD
3500
2610
2354
2670
2750
3260
5090
4085
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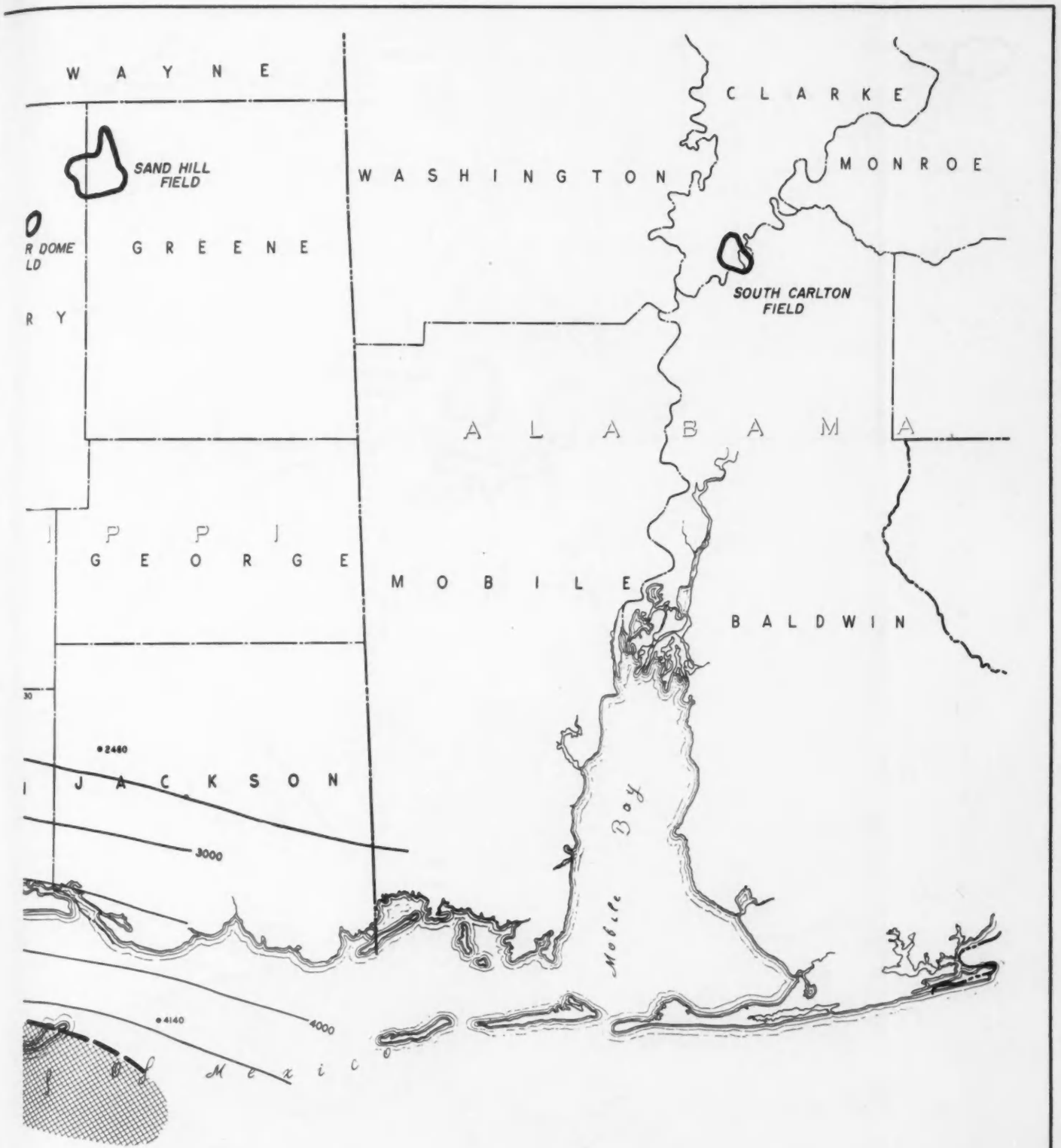
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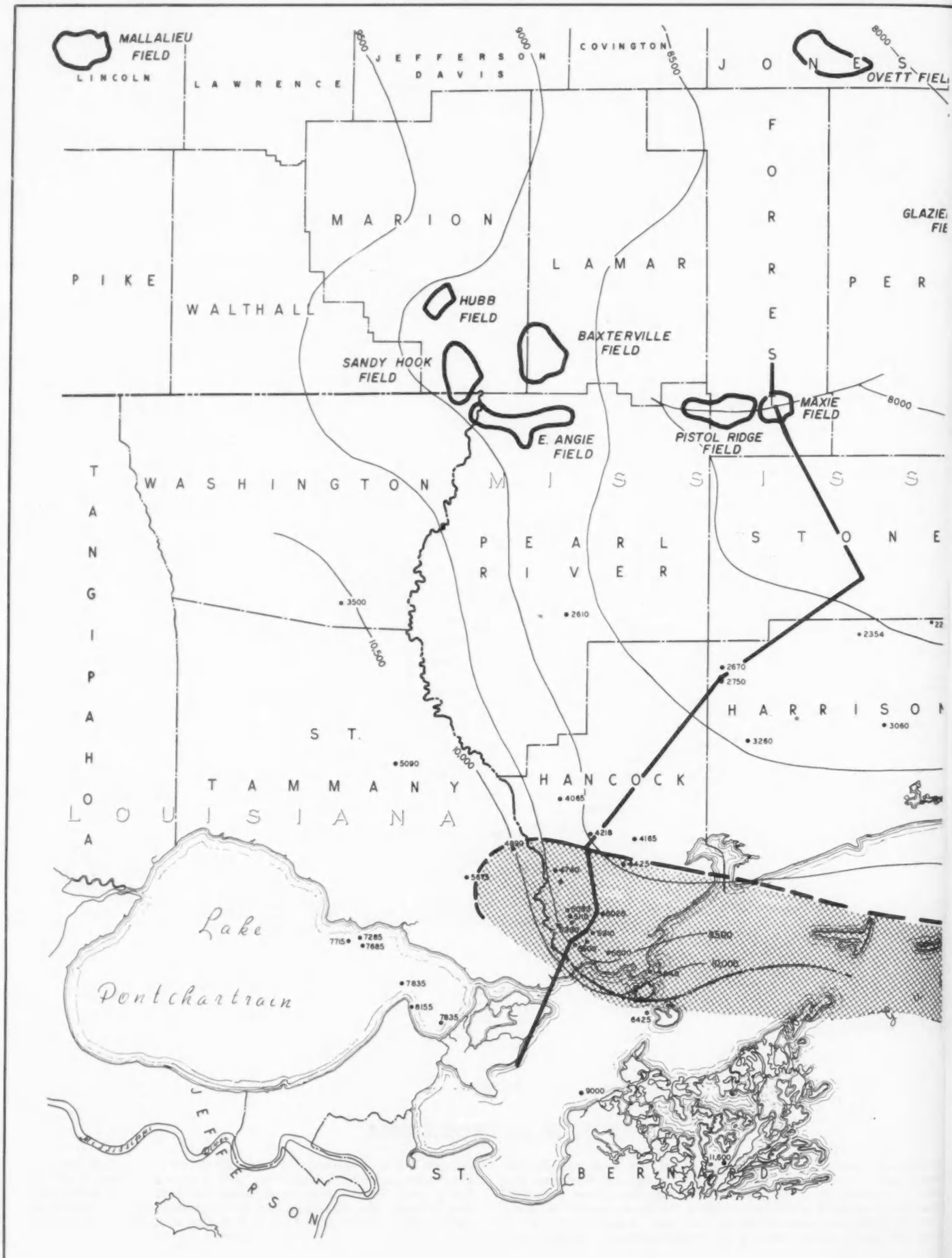
SAND HILL FIELD
R DOME LD
R Y
G R E E N E
W A S H I N G T O N
C L A R K E
M O N R O E
SOUTH CARLTON FIELD
A L A B A M A
G E O R G E
M O B I L E
B A L D W I N
J A C K S O N
2480
3000
4000
4140
Mobile Bay
Gulf of Mexico

FIGURE 2

TOP OF HETEROSTEGINA

In Hancock County, the Heterostegina is a reef type, near shore, shallow water deposit. Stratigraphic analysis indicates that the formation was initially laid-down at a very gentle rate of dip. The present structural attitude is the result of subsequent tilting. In the vicinity of the hinge line, this tilting may approach 20 degrees. Zones of porosity, with shows of oil and gas, have been found in the Heterostegina. A most significant example is seen in the result of drill stem testing the Sun International Paper—Alexander No. 3. Salt water, with a sufficient volume of gas to fuel a small flare, was recovered during the test. The cross-hatched area indicates the absence of the Frio-Vicksburg, Jackson, Claiborne section. An identical symbol is used in Figures 3 and 4 to show a parallel condition.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E. ANGIE FIELD
PISTOL RIDGE FIELD
MAXIE FIELD
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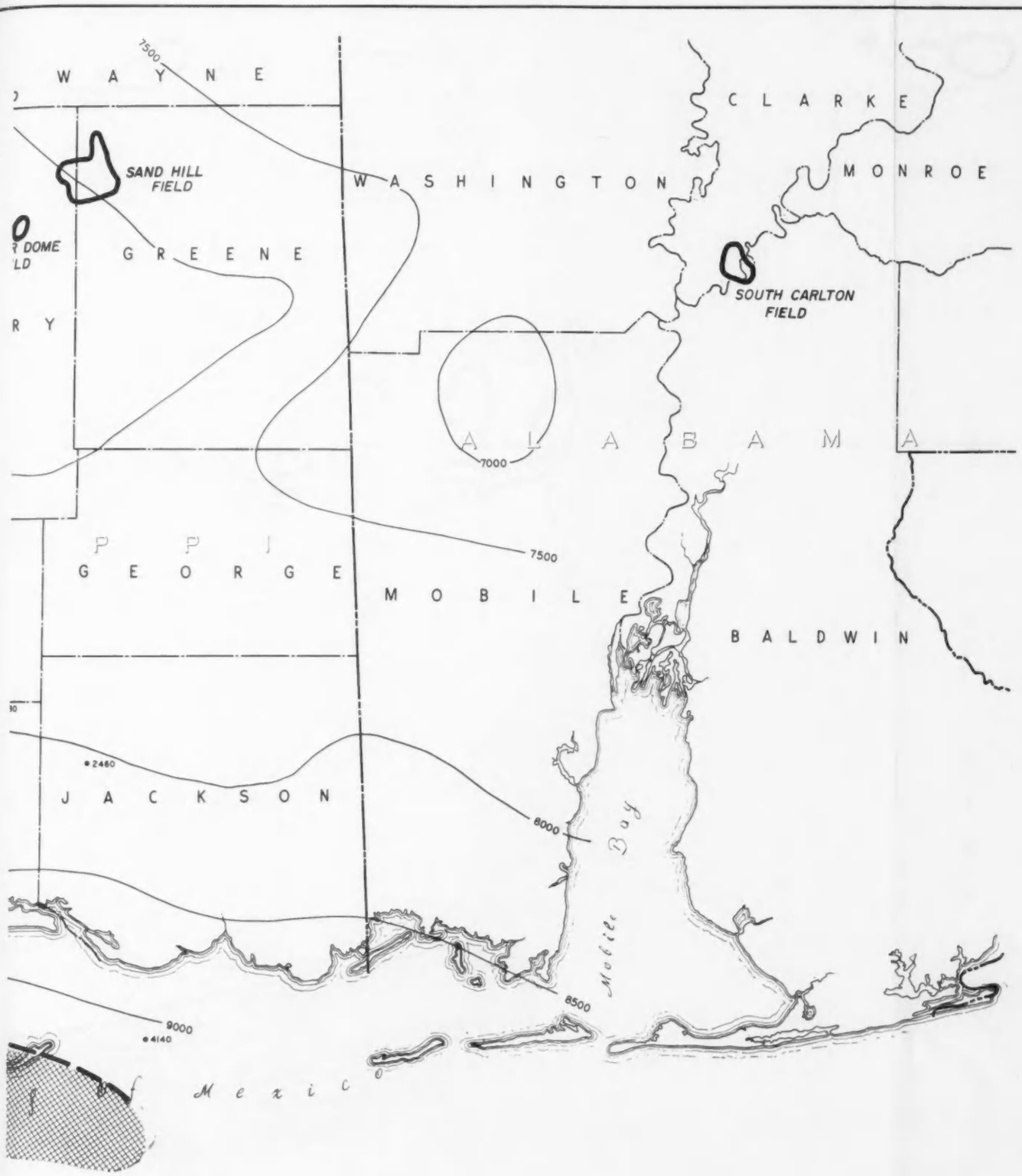
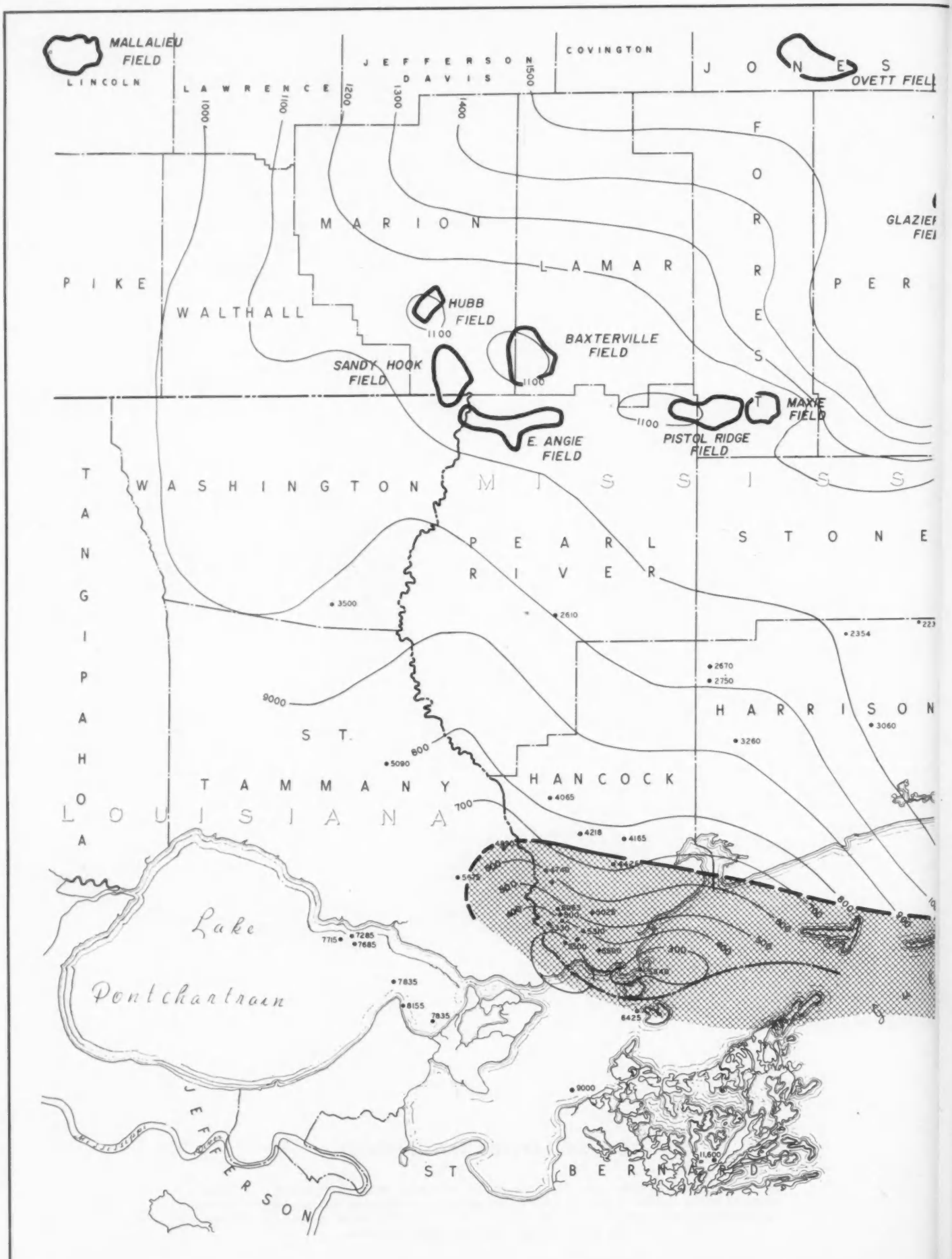


FIGURE 3

TOP OF LOWER TUSCALOOSA

General structural features from the Citronelle to the Ansley field. Development of a hinge is indicated in the vicinity of the Pearl River. The presence of this hinge has aroused considerable curiosity among geologists familiar with the area. An explanation of its presence could lead to the uncovering of other significant structures.


MALLALIEU FIELD
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FORREST
GLAZIER FIELD
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LAMAR
PERRY
PIKE
WALTHALL
HUBB FIELD
BAXTERVILLE FIELD
SANDY HOOK FIELD
E. ANGIE FIELD
PISTOL RIDGE FIELD
MAXIE FIELD
WASHINGTON
MISSISSIPPI
PEARL RIVER
STONE
TANGIPAHOA
ST. TAMMANY
HANCOCK
HARRISON
LOUISIANA
Lake Pontchartrain
JEFFERSON
ST BERNARD
1000
1100
1200
1300
1400
1500
1100
1100
1100
9000
800
700
3500
2610
2354
2670
2750
3060
3260
5090
4065
4218
4165
7715
7285
7685
7835
8155
7835
6425
9000
11,600

W A Y N E
SAND HILL FIELD
G R E E N E
C L A R K E
M O N R O E
W A S H I N G T O N
SOUTH CARLTON FIELD
A L A B A M A
G E O R G E
M O B I L E
B A L D W I N
J A C K S O N
1500
1300
1200
1400
1100
• 2460
• 4140
Mobile
Gulf of Mexico

FIGURE 4

UPPER CRETACEOUS CHALK THICKNESS

Thickness of the upper Cretaceous chalk appears to be one of the most diagnostic bench marks in Mississippi geology. Evidence indicates a definite relationship between chalk thickness and the presence of oil and gas bearing structure.

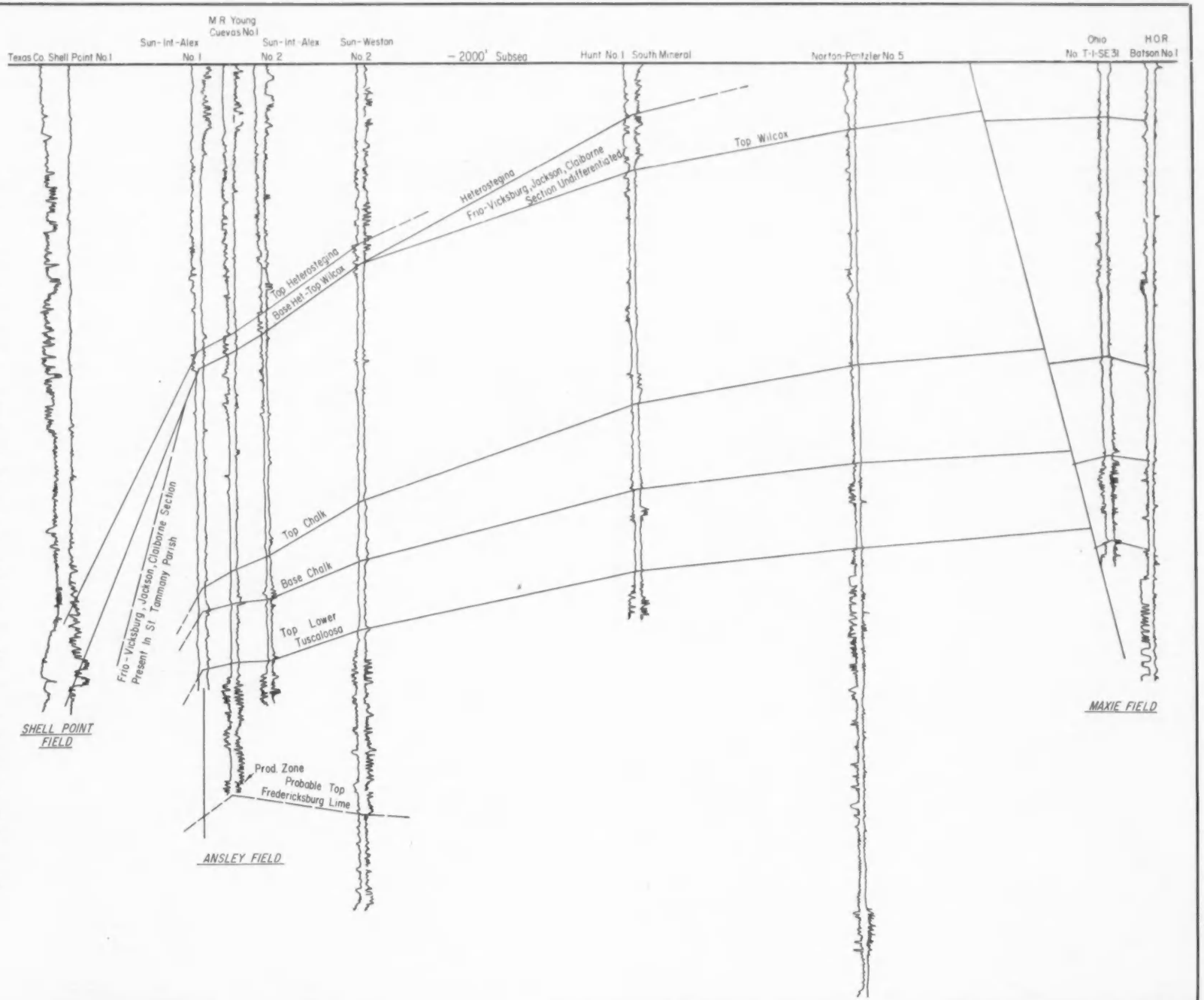

FIGURE 5

Extending from Maxie field to Shell Point field, this cross-section depicts a thinning of beds to the southwest (below the top of the Heterostegina) toward the hinge line where localization is evident. This localization is also indicated by the absence of the Frio-Vicksburg, Jackson, Claiborne section. Between the Shell Point and Ansley areas, the Frio-Vicksburg, Jackson, Claiborne wedge is shown although the author recognizes that the Shell Point well did not penetrate to a sufficient depth for positive correlation. The wedge has been introduced on a basis that the Frio-Vicksburg, Jackson, Claiborne section was found in St. Tammany Parish wells. In certain of these wells, the section exceeds 1700 feet in thickness. This area in southern Hancock County, where the Frio-Vicksburg, Jackson, Claiborne section is missing, and where there is an overall thinning of beds below the Heterostegina, suggests a significant regional uplift.

—The End

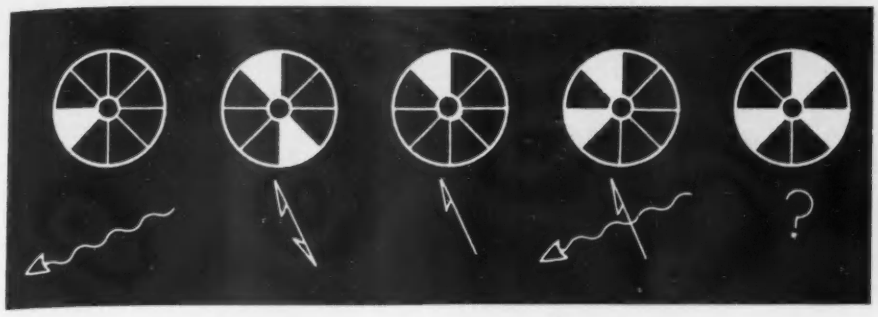

FIGURE 1—Five compasses showing cross-bedding direction measurements and interpretations. The wavy-shafted arrows indicate channel currents, the straight arrows littoral currents.

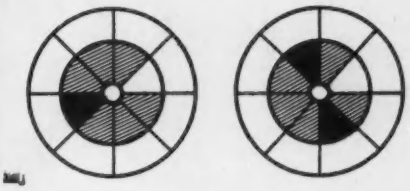

FIGURE 2—Two compasses showing preferred directions (solid black), directions which occur rarely (white) and which therefore suggest a source, and common directions (shaded). The first compass represents channel deposits, and second littoral deposits.

New Method for Mapping Old Shorelines

Cross-bedding and truncation studies provide the field geologist with a reasonably reliable tool for projecting useful stratigraphic information into the subsurface from outcrop areas.

By WILLIAM F. TANNER,
Tallahassee, Florida

As the supply of unexploited structures dwindles, the oil industry turns more and more to the stratigraphic approach for exploration. With this shift of emphasis has come a revival of interest in paleogeography —the business of locating the streams, mountains, oceans, deltas and shorelines of the past.

For oil exploration purposes, deltas, shorelines and near-shore features are of much more interest than mountains, plains and upland rivers. The new style is reflected in titles of symposia, such as "Finding Ancient Shorelines."

But stratigraphic features of this kind can be located only by blind luck—as many have—or by a more advanced knowledge of sediments than we have previously possessed. Hence hand in hand with the new emphasis in exploration has gone a new interest in sedimentologic and stratigraphic research. And out of this research have already come many tools of considerable importance in hunting for stratigraphic oil. Some of these have been paleontologic, based on the ecology of modern microforms such as ostracods and forams. Some, with very involved techniques, have hinged on characteristics of individual sand particles. One such development is a twofold approach based on low-dip unconformities plus oriented features of bedded rocks.

Neither of these ideas is particularly new. Each has been used, in one form or another, for a long time. The combination, and some of the details, however, represent contributions of the last few years.

Oriented features within sediments include those things which possess direction. A fusulinid shell has a long axis, which may be placed in a certain position when the shell is dropped from a flowing current. An elongated mineral grain might be deposited with the same orientation. Each indicates the direction in which the current was flowing. Ripple marks of the asymmetrical type, plant stem fragments, filled channels and bars all possess direction. Cross-bedding is the product of currents, marine or non-marine, which flow more or less steadily, thereby giving their deposits preferred orientation. All of these features, plus others, can be observed in the field, and the observations reduced to compass diagrams in the lab.

Cross-bedding may be thought of as being in two categories: that having relatively high inclination (i.e., 8 degrees or more) and therefore easily measured in the field; and that having low inclination (i.e., less than 8 degrees) and therefore less useful in rapid work. "High dip" cross-bedding is preferable to the "low dip" variety.

Examination of thousands of examples of cross-bedding and other oriented features has resulted in the establishment of certain compass patterns which are easily recognized and interpreted. Five common patterns, of which only one is puzzling, are included in Figure 1. Each can be placed in one or two categories. In each compass, preferred directions of cross-bedding are shown by solid black ink. Interpretations include:

- Channel deposits, indicated by an arrow with a "meandering" shaft.
- Littoral currents in opposite directions, indicated by an arrow with a head at each end.
- Littoral currents in one direction only.

In Figure 2, the compasses show not

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for high-production seismic work

B. J. White, of GSI Offshore Party 307, faces an imposing array of electronic equipment. As an observer, White must work rapidly, for there is little time between shots on this high-production marine seismic party. But with broad-band magnetic recording, White is assured of obtaining all data needed for a precision seismic picture of the prospect.

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Write for Bulletin 56-1, describing GSI's facilities for conducting world-wide seismic and gravity-magnetic surveys.

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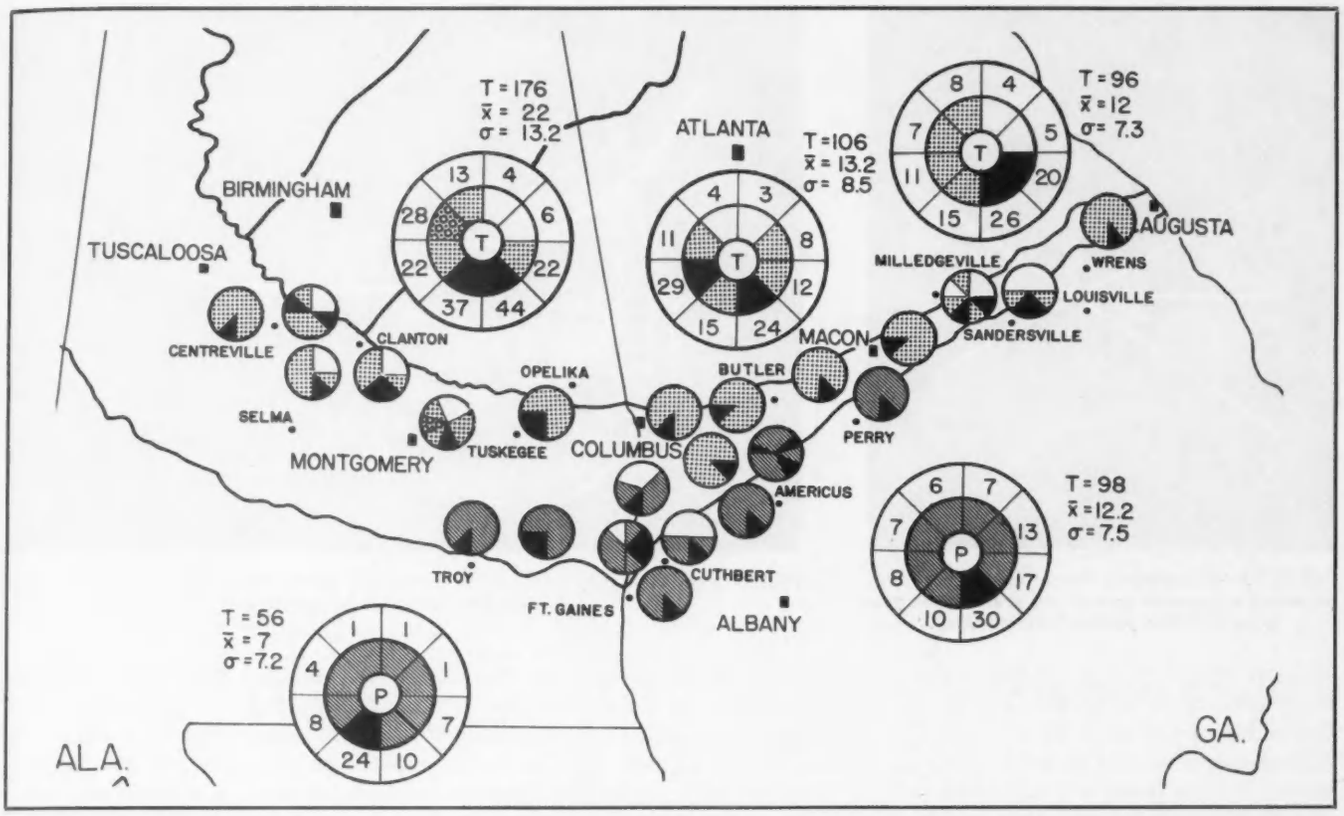

FIGURE 3—Cross-bedding inclination directions for Tuscaloosa and Providence sands of Alabama and Georgia. Tuscaloosa compasses are stippled, Providence compasses are lined. Small compasses represent local measurements, large compasses regional measurements. Parameters listed for large compasses are: total number of measurements (T), arithmetic mean ($\bar{x}$), and standard deviation (σ).

only preferred directions of cross-bedding, but also the directions avoided by the cross-bedding. For channel deposits, it is obvious that very rarely will cross-bedding "dip" upstream. It may be concluded, therefore, that "unpopular" directions indicate the source of a current. The "source directions" are suggested by the white areas in the compasses of Figure 2. In some instances the interpretation of the "source direction" agrees with the interpretations of the preferred directions; in other instances one method yields information which the other method does not.

Compasses of actual field data may be plotted so that preferred orientations are solid black, "source directions" are white, and all other directions are shaded. Such compasses commonly permit fairly reliable interpretations. Where a single compass is questionable, a group of compasses may provide a reasonably certain answer. The trend of the shoreline and the relative positions of land and sea are quite clear.

The compasses given in the first four figures are divided into octants.

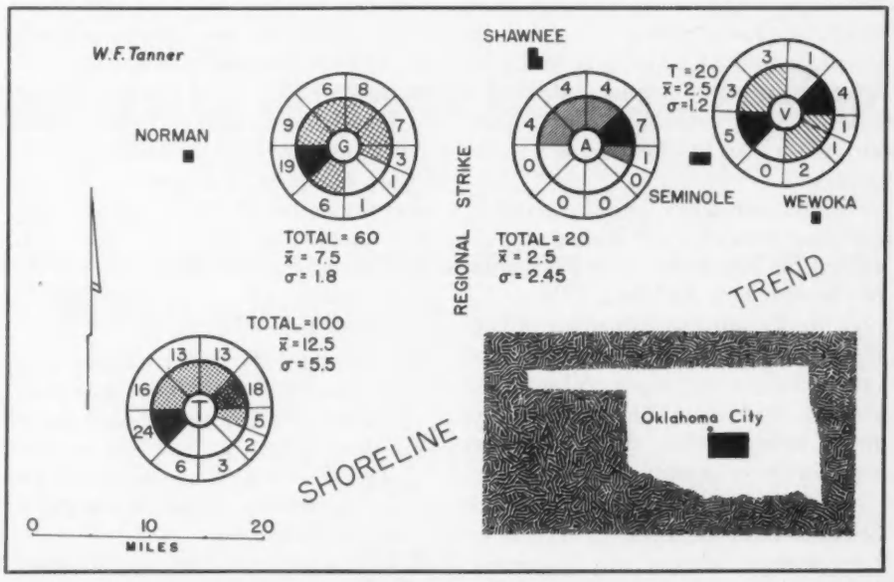

FIGURE 4—Cross-bedding inclination directions for (Permian) Garber and Asher and (Pennsylvanian) Vamoosa formations of central Oklahoma. Garber compass is cross-hatched, Asher compass heavily lined. Vamoosa compass lightly lined, and regional compass stippled. Inset shows location of area. Reconstruction of shoreline is discussed in test. Conventions as in Figure 3.

For most purposes eight divisions are adequate. Where a slight gain in accuracy is desired, each octant may be divided, yielding a total of 16 divisions. For greater accuracy, an "average" direction can be computed. Since ordinary averaging methods cannot be used for circular (i.e., compass) data, some other procedure, such as drawing vector sums, must be followed.

When field data have been collected, it is important that the geologist decide wisely which directions are really significant. For instance, the number of measurements falling in the various octants might be as fol-

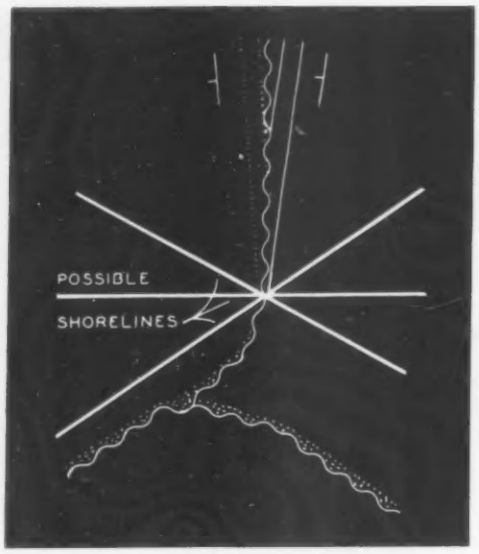

FIGURE 5—Unconformity trace (wavy line) approaching a mountain area to the south. Three possible shoreline positions are indicated.

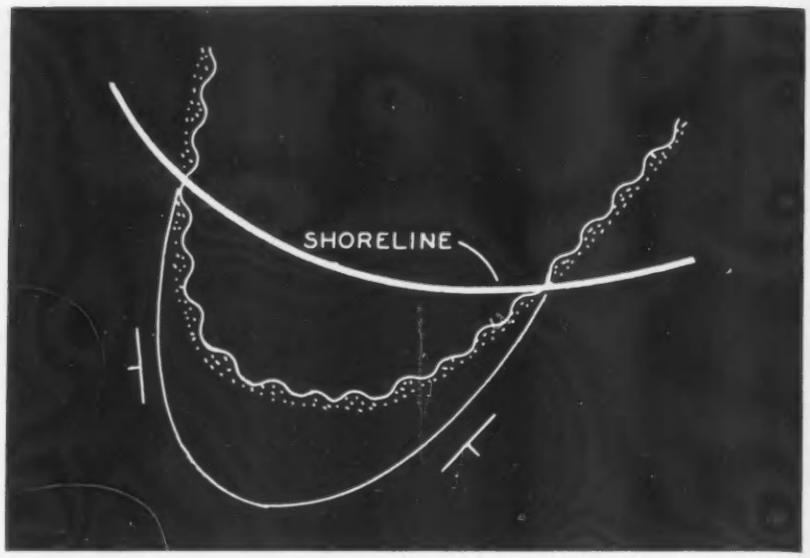

FIGURE 6—Unconformity trace circling a mountain area to the north. One highly probable shoreline position is indicated.

lows: 5, 4, 3, 2, 1, 1, 0, 0. Are any of these octants to be shaded black, or left white, or will all of them be gray? Calculation of simple statistical values shows that the mean is 2 (i.e., total of 16, divided by 8 octants), and the standard deviation is about 1.7. Anything higher than 3.7 (that is, 2+1.7) may be taken as significantly high; two octants fall in this category. And anything lower than 0.3 (that is, 2 — 1.7) may be taken as significantly low; again, two octants fall in this category. The remaining four octants are too close to the average to be useful.

Actual compasses, and the paleogeographic data derived from them, are shown for two areas: the Cretaceous of Georgia and Alabama (Figure 3), and the Permo-Pennsylvanian of central Oklahoma (Figure 4). Work on other sediments, from Silurian to Recent, and from Florida to Colorado, indicate that these maps are representative examples.

In some instances, maps based on oriented data are open to several interpretations, or are only suggestive. Where the conclusions are not clear-cut, or the preferred directions need to be pin-pointed more accurately for extension into the subsurface, additional information may be obtained from analysis of low-dip unconformities. Such analysis is most profitable where the angles involved are two degrees or less, but can be carried out with angles up to about six degrees. No lower limit is known; problems of this type have been worked where pertinent angles were about five minutes.

Low-dip unconformities are commonly exposed as a result of uplifts other than those which were responsible for the initial erosion interval. If the former and latter uplifts are located in adjacent but distinct areas, and are about equal in terms of feet of elevation, the strikes of the rocks and the traces of the unconformities will be rotated to directions other than those on the paleogeographic map. This rotation may approach 90 degrees.

The shoreline does not change position appreciably as a result of either uplift. However, the rotation of strikes and unconformity traces permits certain deductions about the subsurface position of the shoreline.

In general, one of the following will be found to hold true:

1. Unconformity traces which merge, at one end, with more important unconformities, and vanish, in the other direction, into the section. The direction of the shoreline can be inferred, within a range of about 90 degrees.
2. Unconformity traces which merge, at both ends, with more important unconformities. The direction of the shoreline can be inferred within a range of a few degrees, the precise amount varying from one area to another.

Two examples are given, one (Figure 5) for the more difficult first case, and the other (Figure 6) for the second case.

In many instances the two lines of approach—stratigraphic and structural—yield essentially identical answers, providing reasonable assurance for the accuracy of the interpretation. In other instances the information obtained in the two different ways is complementary, providing one well-unified paleogeographic pattern, but with less assurance.

One of the results of this research has been to show that many so-called continental sandstones were deposited under near-shore marine conditions; that is, that shorelines were farther inland than was previously thought. This discovery has led to the conclusion that "shoreline" oil is, commonly, actually obtained from offshore sand trends which may have been tens of miles from the actual beach. A revision of much thinking about environments is indicated.

Another result has been to provide the field geologist with a reasonably reliable tool for projecting useful stratigraphic information into the subsurface from outcrop areas. With the recent development of rapid methods of determining grain orientation from cores, the subsurface geologist has been handed a powerful instrument to be used in the future search for stratigraphic oil.

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ACKNOWLEDGMENT

Figures 3 & 4 courtesy *Bulletin of the American Association of Petroleum Geologists.*

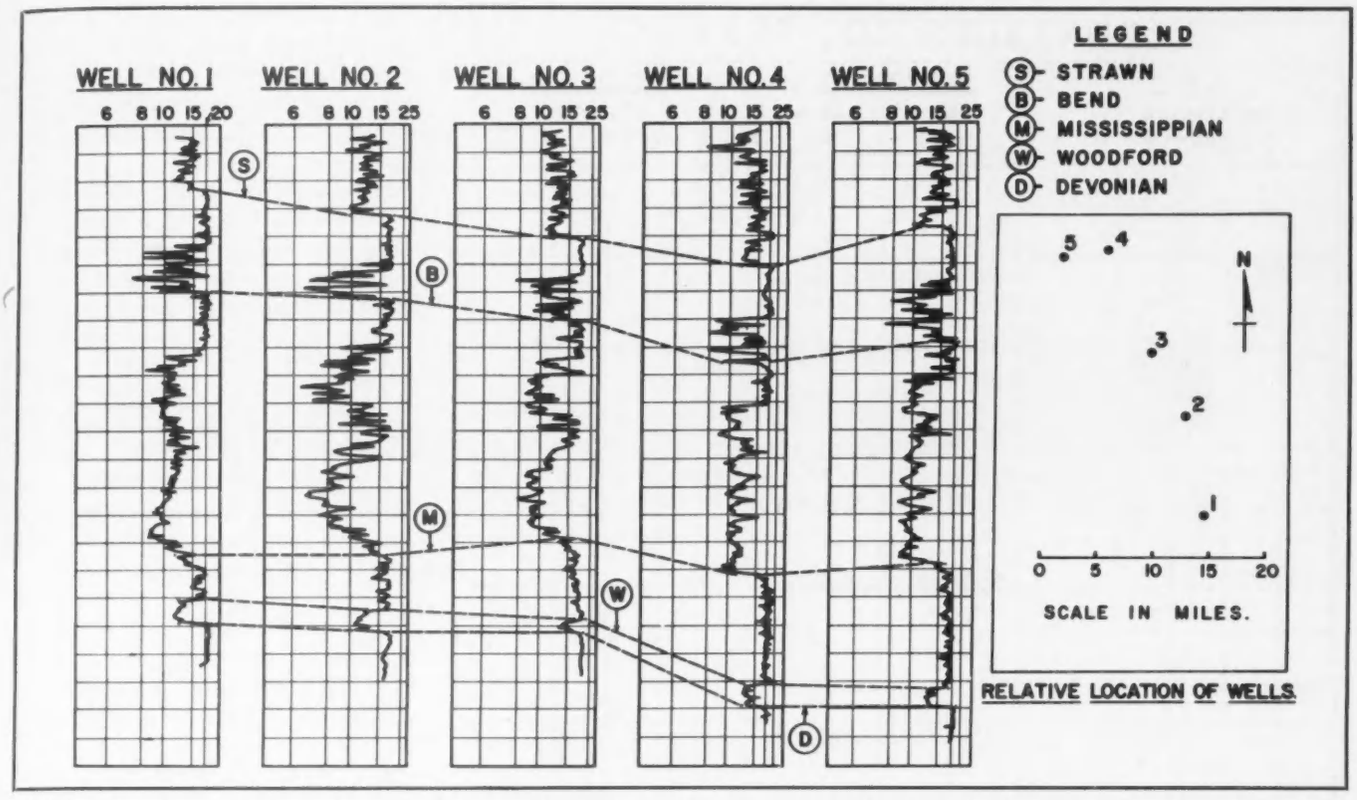


FIGURE 1—Correlation of velocity logs from wells over a 30-mile distance in Andrews and Midland counties, Texas. Logs are adjusted to sea-level datum, so that the structural relationship is correct.

Exploration Geophysics Makes Rapid Strides

The past year has seen several instruments and techniques advance beyond the development stage. Healthy dissatisfaction typifies the industry.

By MILTON B. DORBIN and ROBERT G. VAN NOSTRAND
Magnolia Petroleum Company, Dallas

THE PAST YEAR has seen exploration geophysics make its greatest progress in the application to prospecting of instruments and techniques which were until recently only in the development stage. Most notable examples are magnetic recording and velocity logging, both of which are being offered already as commercial services.

Use of magnetic recording permits greater flexibility in seismic interpretation; automatic time correction, facilitating compositing as well as preparation of record sections; and the ready storage of seismic data in a form suitable for any processing procedures that may be developed in the future. Interval velocity logs have given geophysicists a better understanding of the origin of reflections from a complexly layered section. This understanding should lead to a more realistic interpretation of reflection data, and may eventually make it possible to map stratigraphic as well as structural features.

Other noteworthy developments in seismic prospecting during 1955 include new methods for generating seismic energy, novel approaches to the improvement of signal-to-noise ratio, and application of high frequency techniques in oil exploration.

Although current research in petroleum geophysics is concentrated more than ever on seismic techniques, there have been important developments in the application of other geophysical

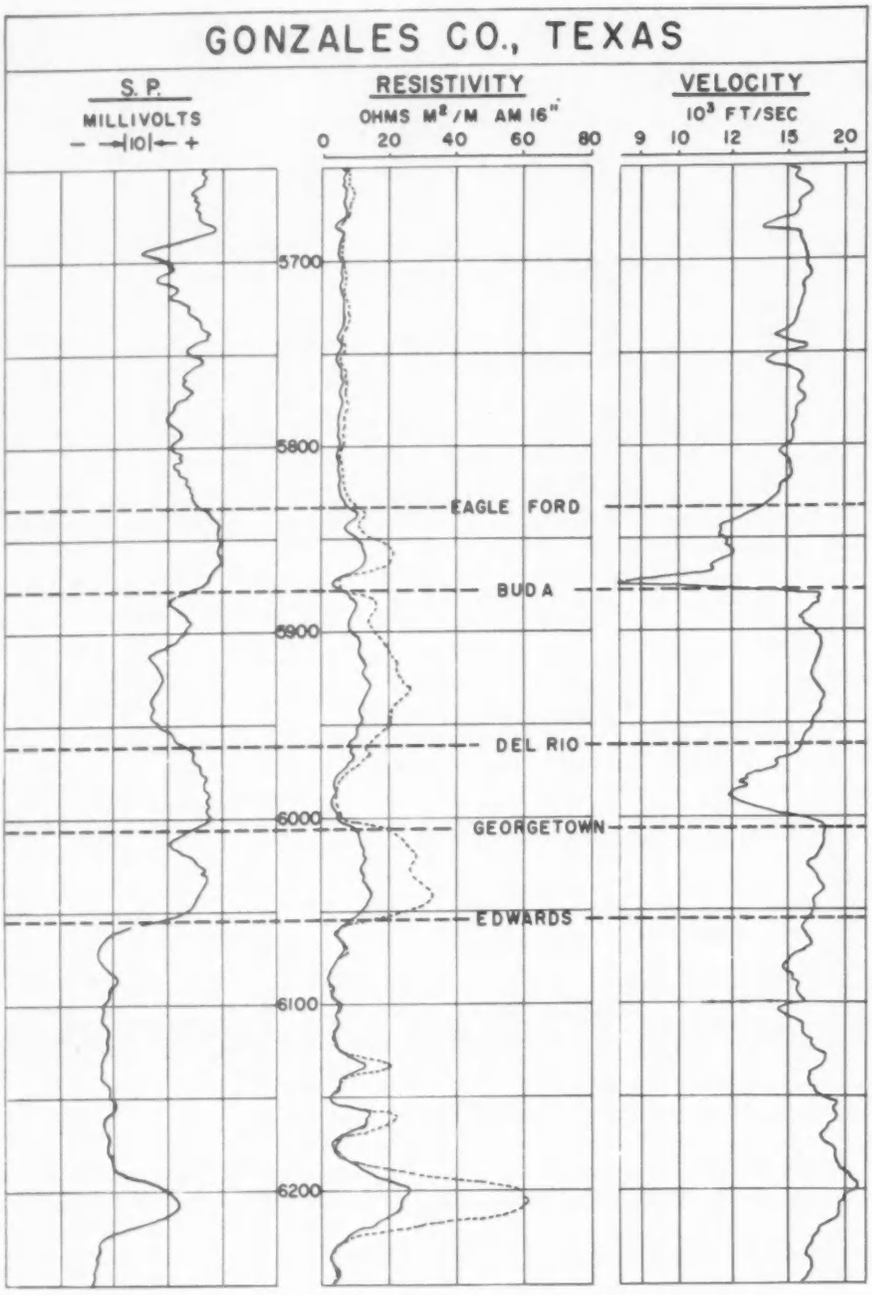


FIGURE 2—Velocity, resistivity, and self-potential logs in a well in Gonzales County, Texas.

methods to petroleum prospecting, mining exploration and to engineering problems. The gamma-gamma logger now gives density data that are sufficiently reliable for gravity interpretation; an induced polarization method has been successful in finding ground water; and airborne electro-magnetic methods have been widely used in the search for base metals in Canada. A new type of airborne magnetometer based on nuclear magnetic resonance has gone into service in prospecting for iron ore in the western U. S. This device is adapted particularly for use in light aircraft.

The rapidity of current technological improvement in exploration geophysics is attributed to the acceleration of geophysical research activity in the oil industry after World War II, to productive fundamental research, and to a widespread attitude among geophysicists of dissatisfaction with existing techniques.

Magnetic recording. First consider the status of magnetic recording. A survey conducted the latter part of 1955 indicated that 145 magnetic recorders have been delivered by manufacturers while 36 units were in the process of fabrication. With delivery of the 36 units, there was an average of one recording unit in service for every five seismic crews operating during the first half of 1955. A large majority of the total number of units were manufactured during the year.

Almost half of the playback units in service have heads with adjustable time delay. Thus, a large proportion of existing magnetic playbacks are capable of turning out seismic records of a type that cannot be obtained at all with conventional recording equipment.

Specifically, time shifting makes it possible to adjust for time delays, caused by weathering, elevation, and normal moveout, individually on each trace. This feature particularly is valuable when traces are composited, since mixing of uncorrected traces often causes cancellation of reflections rather than reinforcement. In some areas of poor reflection quality, availability of time-shifting equipment might make the difference between mapping and missing a key reflection in a critical zone.

Two kinds of time shifters are available. The static type keeps the same time difference between traces all through the playback of a record.

In addition to time shifters, several other devices have been developed for processing seismic data recorded magnetically. Among these are time domain, or delay line, filters. In a filter of this type the signal is picked up from a drum surrounded by a number of spaced heads with adjustable sensitivities. The weighted output of the heads are added, the resultant signal having a spectrum depending on individual sensitivity settings. This procedure gives great flexibility in filtering but it is practical only if the traces are played back sequentially.

Another data-handling operation made more feasible by magnetic recording is trace multiplication. Under favorable circumstances, this will give a better signal-to-noise ratio than trace addition.

Magnetic recording is still so new that there is a wide variation in attitudes among geophysicists as to its place in seismic exploration. Some look upon it only as a tool for research studies which require exceptional flexibility in data storage. At its present stage, they feel that it is too expensive for exploration work.

Others believe that magnetic tape justifies its cost only in certain prob-

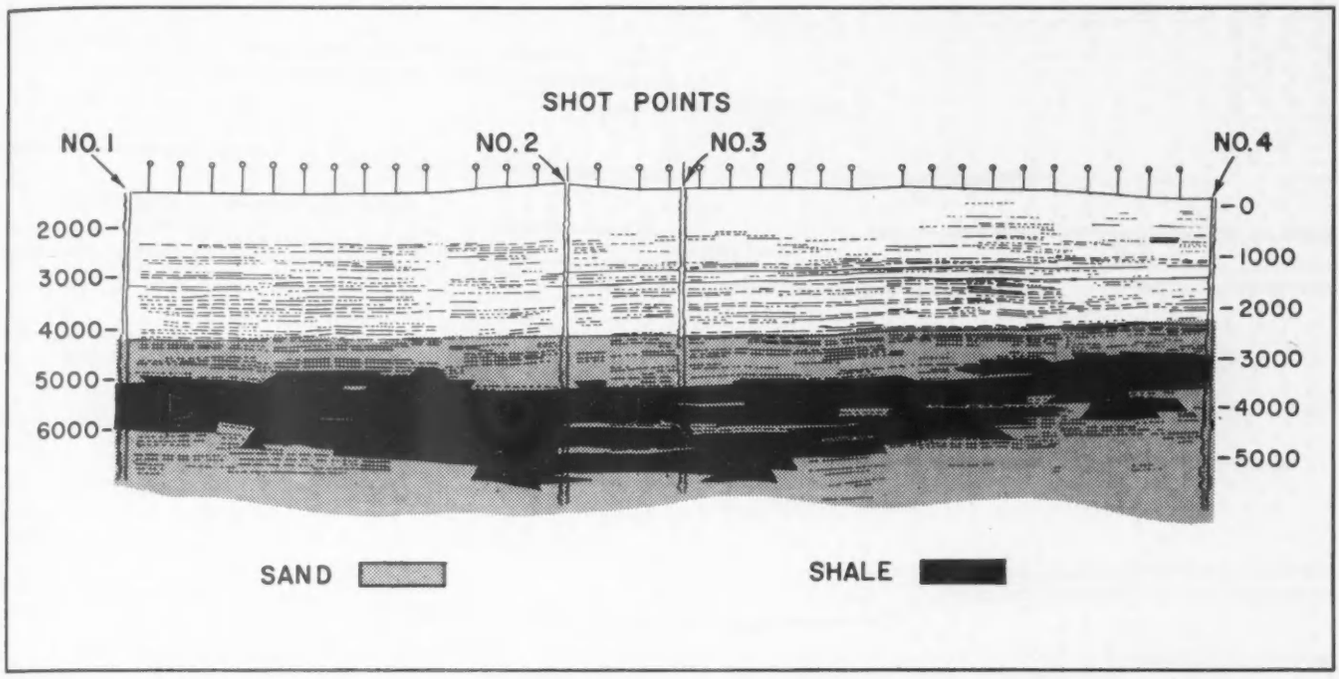


FIGURE 3—Seismic cross-section in Gonzales County, Texas. Dark part of section is region of no reflections and is interpreted on the basis of electric logs as being shale.

lem areas. They recognize the advantages, where stratigraphy or structure is complicated, of being able to play records back through a wide variety of filters without having to worry about the shot-point variable. Also, where record quality is poor, the ability to shift times before compositing may well improve records enough to justify the added cost of magnetic equipment.

To an increasing number of geophysicists, however, magnetic recording appears desirable for all seismic shooting. In their opinion, it is important to be able to store seismic data covering the entire range of usable frequencies, in reproducible form. From the standpoint of economics, such storage could save the cost of reshooting at some future time if new data-handling procedures should be developed which would make it possible to get more or better information from seismic shooting than is presently obtainable. This viewpoint involves something of a gamble since there is no guarantee that such improvements will ever appear, but geophysicists have gambled before and won.

Acoustic velocity logging. Closely related in importance to magnetic recording is acoustic velocity logging. Here also activity has grown tremendously during the past year or so.

At the outset, most velocity logging devices were designed primarily for getting seismic velocity information more conveniently than with conventional well shooting. As experience has been gained with them, many additional uses have become apparent which may turn out to be more important. In some areas, correlation has been more satisfactory with velocity logs than with any other type of log. Figure 1 shows an example of such correlation over a distance of 30 miles in Andrews and Midland counties, Texas.

Often a velocity log will give the geologist a more reliable basis for picking a formation top than an electric log in the same hole. Figure 2 shows how contrast in velocity at the top of the Buda formation in Gonzales County, Texas, is much more distinctive than contrast in resistivity or self-potential at the same interface.

Greatest potential usefulness of velocity logs lies in the improved insight they can give on origin of seismic reflections. Such an insight should enable the entire process of seismic interpretation to be put on a sounder and more satisfactory basis.

Interval velocity logs show that the variation of elastic properties with depth in the earth is much more complex than generally has been realized. Within a vertical distance corresponding to a wavelength, there is usually a large number of contrasts in velocity. A study of these features leads to the realization that the reflections actually seen on seismic records represent a composite of events from these many individual interfaces.

What is called reflection character depends most critically on the thicknesses and velocities of the respective individual strata. Small variations in the spacing or elastic characteristics of these beds may cause substantial changes in character.

High-frequency seismic recording. An important consequence of this type of study has been a better understanding of the frequency characteristics of waves reflected from various formations. Such an understanding is needed if full advantage is to be taken of the great flexibility in filtering obtainable with magnetic records. When layering is thin, for example, the best reflection information can often be obtained at frequencies which are much higher than those conventionally used in seismic work.

One company is offering contract service with special equipment which operates only in the range from 55 to about 300 cps. Originally designed for mining and engineering investigations at shallow depths, this system has

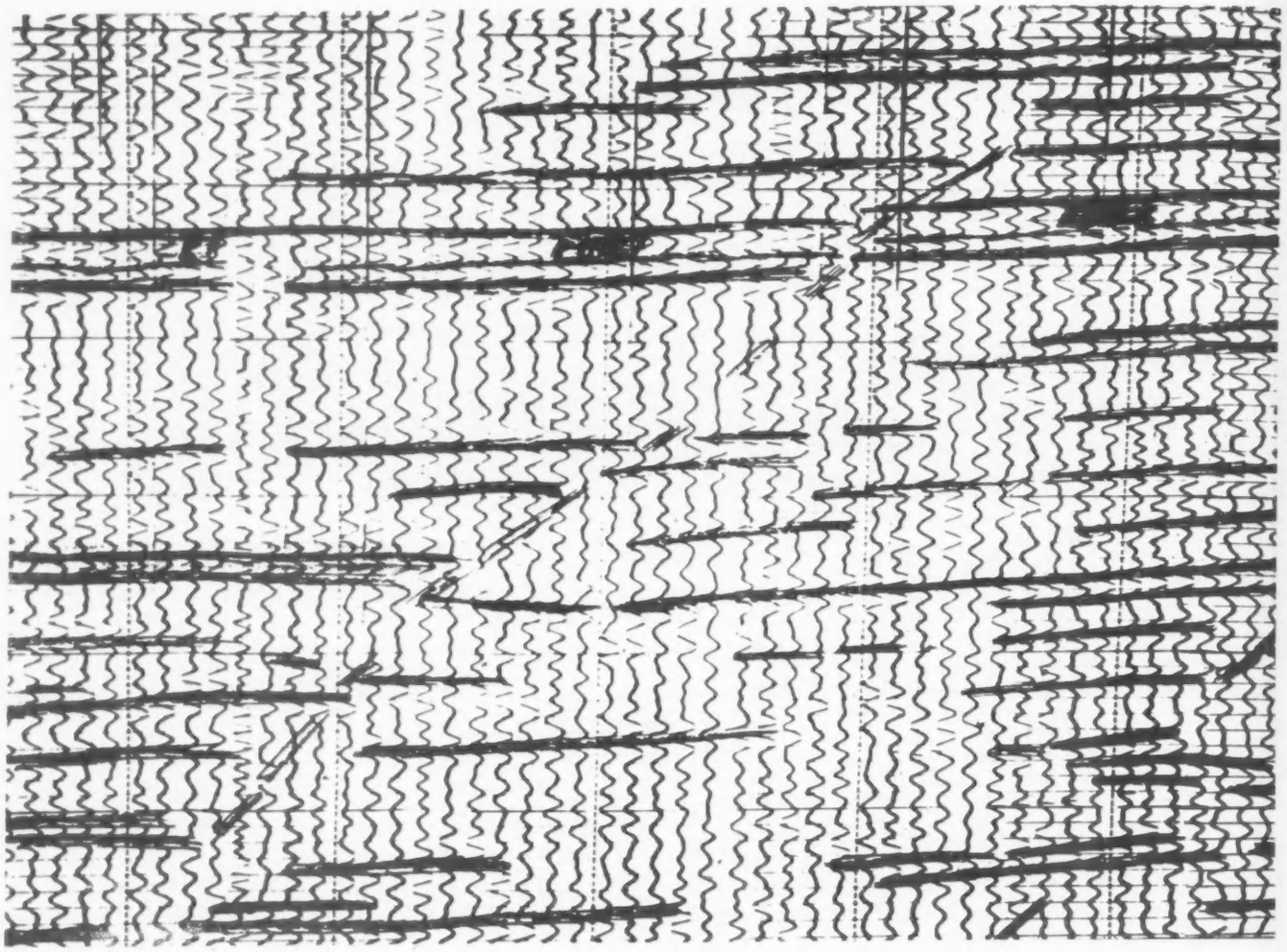


FIGURE 4—Record section made with mechanical plotters from records originally recorded on magnetic tape in Southern Louisiana. Section is traversed by a small fault.

turned out to give unexpectedly useful information in oil exploration.

In areas of complex structure, use of high frequencies with close geophone spacing has made it possible to map steep dips, overthrusting, and unconformities within the first few thousand feet of section. Such features could not ordinarily be resolved by conventional shooting techniques.

High frequencies also have been used for detailing shale bodies surrounded by sand. In general, shale is much more homogeneous than sand and contains few if any reflecting interfaces. The sand, on the other hand, will usually be interspersed with thin shaly zones which are so closely spaced that they give reflections that can be detected only through high-frequency filters. On a high-frequency seismic record, then, a thick shale section should be represented by an absence of reflections and a sand section by a high density of reflections.

Figure 3 shows a seismic cross-section obtained by a crew in Gonzales County, Texas. Here the configuration of the middle Wilcox shale was determined on the basis of reflection density. The thickening or thinning of the shale between wells as indicated by the electric logs is reflected in the shape of the reflection-segment envelope corresponding to the sand-shale boundary.

Presentation of seismic data. During the past year, the geophysical industry has put much effort into improvement of methods for presenting seismic data. Record sections particularly have been popular because they aid the interpreter in visualizing his subsurface picture and, also, because they make it easy to present raw seismic data to the geologist and exploration executive in a form that conveys the most information.

A new mechanical plotter was developed to transform traces on seismic records into a form more suitable for presentation in a vertical cross-section. A complex optical system shifts the signals along a time axis to compensate for weathering, elevation, and normal moveout. It also transforms the time scale on the records to a depth scale on the section.

Figure 4 shows a mechanical plotter record section made from records originally shot on magnetic tape in South Louisiana. The section gives evidence of a small fault in the Frio at a depth of about 10,000 feet. The record was played back from the tape through a high frequency filter, and the section indicates the usefulness of such frequencies in resolving faults with a small throw.

The dynamic head shifter on magnetic playback units also makes it possible to construct record sections on which normal moveout and other irregularities are removed. Figure 5 shows a portion of a record section made with one company's dynamic head shifter which yields a cross-section on a time rather than a depth scale. The time-shifting corrects for moveout so effectively that reflections at four or five-tenths of a second can be followed. These would normally have such a large stepout that they

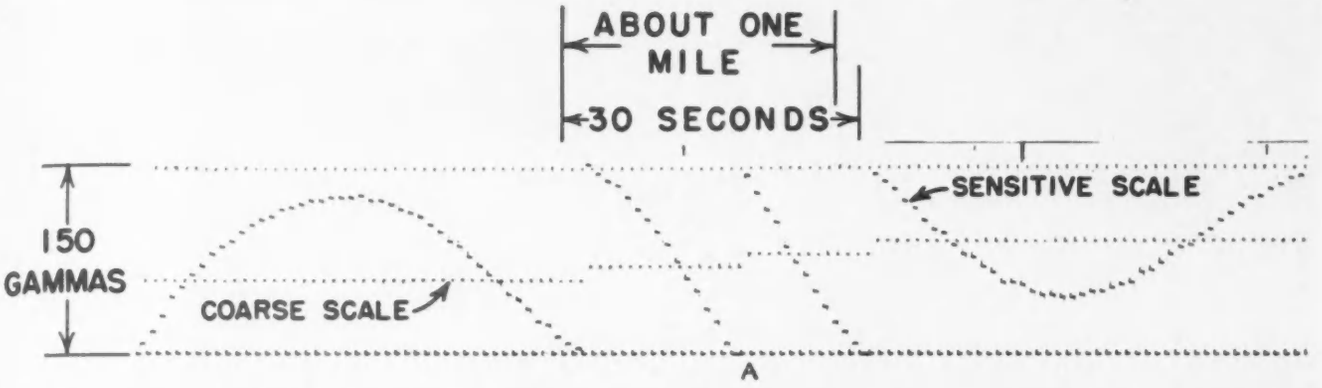


FIGURE 7—Sample record of the airborne magnetometer using nuclear magnetic resonance. Energizing current is applied for one-half second and output is measured for next half-second, resulting in closely spaced but discontinuous signals on record.

could be correlated only with great difficulty.

Another oil company is experimenting with record sections on variable density film. These should look more like geological-cross sections than any which use the conventional type of presentation.

Other seismic developments. Several other important developments in seismic prospecting should be mentioned. The thumper, which generates seismic energy by dropping a 3-ton weight on the earth, has seen increasing use during the past year. At least seven thumper crews are now in operation. Because of the large amount of magnetic tape required for recording the many individual drops that are composited to make up each final record, thumper operations are said to use up more than half of all such tape that is manufactured. Recently the system has gone to sea. The weight has been dropped on the surface of the water in Galveston Bay and, according to reports, has given good records there.

Because of an increase in reconnaissance-type exploration during the past year or so, there has been a resurgence of activity in refraction prospecting. One contractor has six refraction crews in operation, mostly outside the U. S. This work is carried on with a new geophone and recording system that make it possible to go to frequencies as low as 2 cps.

Gravity, magnetic, and electrical prospecting. In gravity prospecting, new developments have not been as numerous over the past year as in the seismic field. A new and improved model of the gamma-gamma density logger has been constructed and the data it gives appear to be adequate generally for gravity interpretation but not for porosity determination. Evaluation of this tool by a number of oil companies is continuing on a cooperative basis. Meanwhile it is being used operationally in many areas to get density data for gravity work.

Last winter, the first gravity contour map to have been constructed in a vertical plane was presented at the annual convention of the AIME in Chicago. Data for this map, which is shown in Figure 6, were obtained in the shafts and adits of a copper mine near Bisbee, Ariz. The pronounced high-gravity axis is shown to project into the unexplored area, suggesting the direction that further development of the mine property should take.

In magnetic prospecting, one development of the past year particularly worthy of mention. At the St. Louis meeting of the SEG in April, 1954, a new type magnetometer based on nuclear magnetic resonance was described. This instrument could measure absolute earth fields in the laboratory with an accuracy of one gamma. Within the past few months, this magnetometer has been adapted for operation in a light airplane and is now being used in actual surveys for iron ore in northern California. Installation consists of a small bird towed at the end of an 80-foot cable. The bird contains only a magnetic coil and a 1-liter bottle of water.

Figure 7 shows a sample record made with this device. Readings are recorded once a second, and the full-scale sensitivity of 150 gammas gives data quite comparable to what can be obtained from fluxgate-type magnetometers.

In electrical prospecting, most noteworthy trend of the past year has been a rapid increase in number of airborne electromagnetic surveys for base-metals. Two contract companies have been offering this service, and at least two mining companies have been making electromagnetic surveys from their own planes.

Promising advances have been made in electrical exploration for ground water by Prof. Vacquier of the New Mexico Institute of Mining and Technology, who has developed an induced polarization method for this purpose. His technique seems particularly suitable for determining depth of the water table in desert areas.

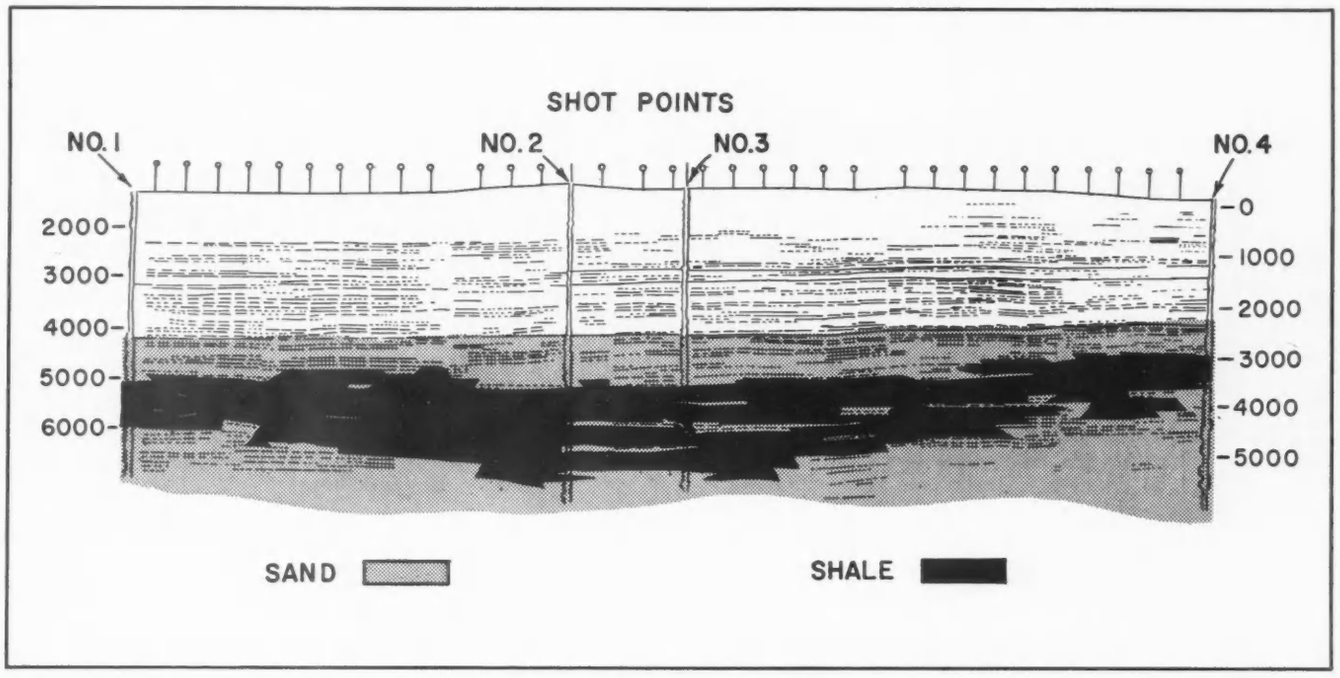
Fundamental studies. In the foregoing discussion, limitations of space have prevented the review of important fundamental research going on in geophysics at universities, in government instititions, and in endowed laboratories. Some of this work may well lead to improvements in exploration techniques. The principle of nuclear magnetic resonance, for example, was discovered in university laboratories only a few years ago and already it is being used in search for iron ore.

Some of the geophysical research at academic institutions is being supported by the oil industry. One example is the work of the Geophysical Analysis Group at MIT which is investigating statistical techniques for improving seismic reflection data.

Dr. Dorbin was with Magnolia Petroleum Company at the presentation date of this paper. However, he is now with the Triad Oil Company in Calgary, Canada.

ACKNOWLEDGMENT

This work was sponsored by a Special Committee on Research of the Society of Exploration Geophysicists and was presented before the society at its annual meeting in Denver, October, 1955. A somewhat different version was presented by Van Nostrand before the European Association of Exploration Geophysicists at its meeting in London in December, 1955. The complete paper appeared in the January issue of the Society's journal, *Geophysics*. However, by popular request from our readers, and with permission from *Geophysics*, a simplified, condensed version of the work is being published in World Oil so that those actively engaged in the fields of drilling and production will have the opportunity to become better acquainted with progress in geophysics.



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High-frequency seismic recording. An important consequence of this type of study has been a better understanding of the frequency characteristics of waves reflected from various formations. Such an understanding is needed if full advantage is to be taken of the great flexibility in filtering obtainable with magnetic records. When layering is thin, for example, the best reflection information can often be obtained at frequencies which are much higher than those conventionally used in seismic work.

One company is offering contract service with special equipment which operates only in the range from 55 to about 300 cps. Originally designed for mining and engineering investigations at shallow depths, this system has

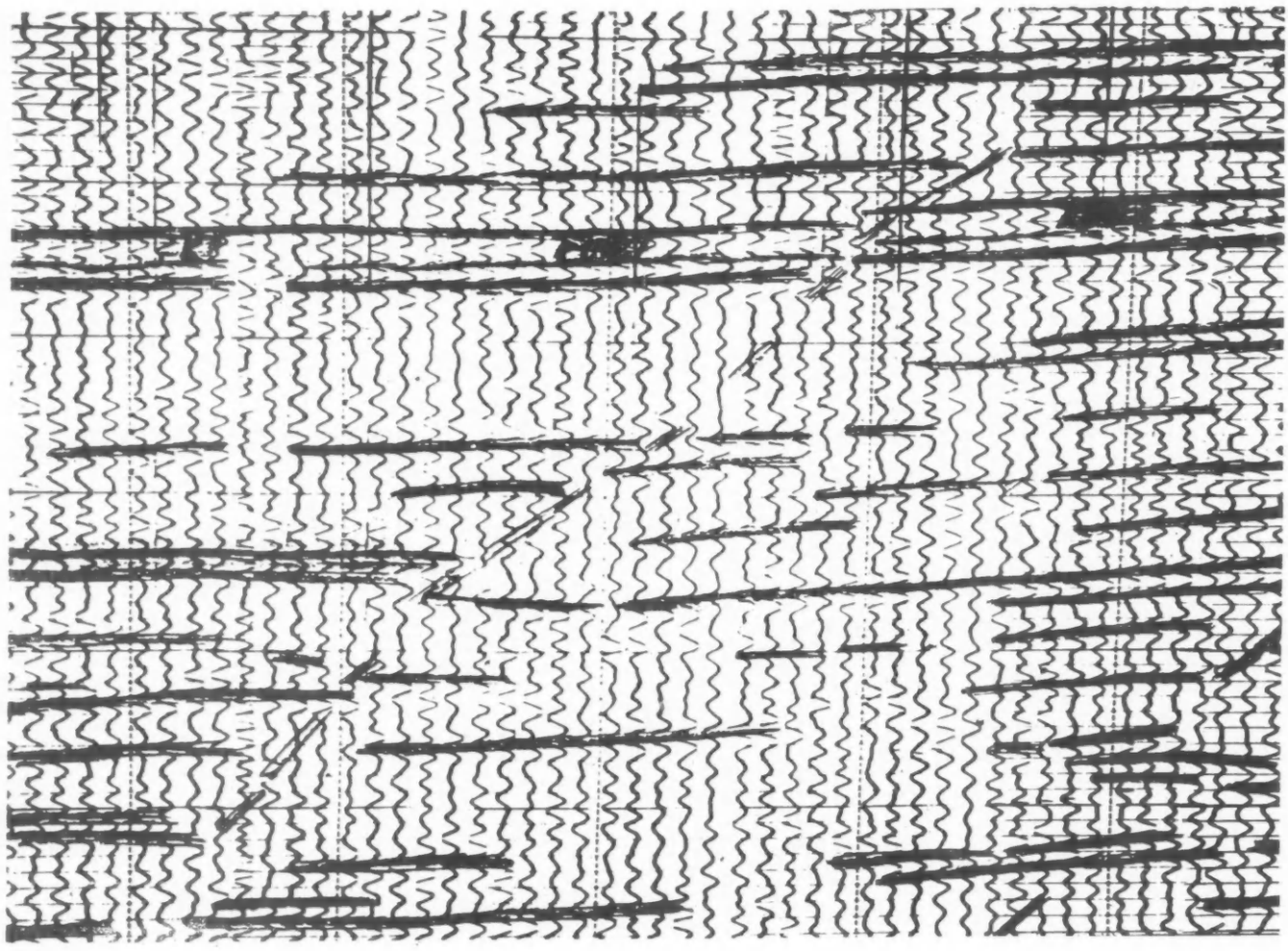

FIGURE 4—Record section made with mechanical plotters from records originally recorded on magnetic tape in Southern Louisiana. Section is traversed by a small fault.

turned out to give unexpectedly useful information in oil exploration.

In areas of complex structure, use of high frequencies with close geophone spacing has made it possible to map steep dips, overthrusting, and unconformities within the first few thousand feet of section. Such features could not ordinarily be resolved by conventional shooting techniques.

High frequencies also have been used for detailing shale bodies surrounded by sand. In general, shale is much more homogeneous than sand and contains few if any reflecting interfaces. The sand, on the other hand, will usually be interspersed with thin shaly zones which are so closely spaced that they give reflections that can be detected only through high-frequency filters. On a high-frequency seismic record, then, a thick shale section should be represented by an absence of reflections and a sand section by a high density of reflections.

Figure 3 shows a seismic cross-section obtained by a crew in Gonzales County, Texas. Here the configuration of the middle Wilcox shale was determined on the basis of reflection density. The thickening or thinning of the shale between wells as indicated by the electric logs is reflected in the shape of the reflection-segment envelope corresponding to the sand-shale boundary.

Presentation of seismic data. During the past year, the geophysical industry has put much effort into improvement of methods for presenting seismic data. Record sections particularly have been popular because they aid the interpreter in visualizing his subsurface picture and, also, because they make it easy to present raw seismic data to the geologist and exploration executive in a form that conveys the most information.

A new mechanical plotter was developed to transform traces on seismic records into a form more suitable for presentation in a vertical cross-section. A complex optical system shifts the signals along a time axis to compensate for weathering, elevation, and normal moveout. It also transforms the time scale on the records to a depth scale on the section.

Figure 4 shows a mechanical plotter record section made from records originally shot on magnetic tape in South Louisiana. The section gives evidence of a small fault in the Frio at a depth of about 10,000 feet. The record was played back from the tape through a high frequency filter, and the section indicates the usefulness of such frequencies in resolving faults with a small throw.

The dynamic head shifter on magnetic playback units also makes it possible to construct record sections on which normal moveout and other irregularities are removed. Figure 5 shows a portion of a record section made with one company's dynamic head shifter which yields a cross-section on a time rather than a depth scale. The time-shifting corrects for moveout so effectively that reflections at four or five-tenths of a second can be followed. These would normally have such a large stepout that they

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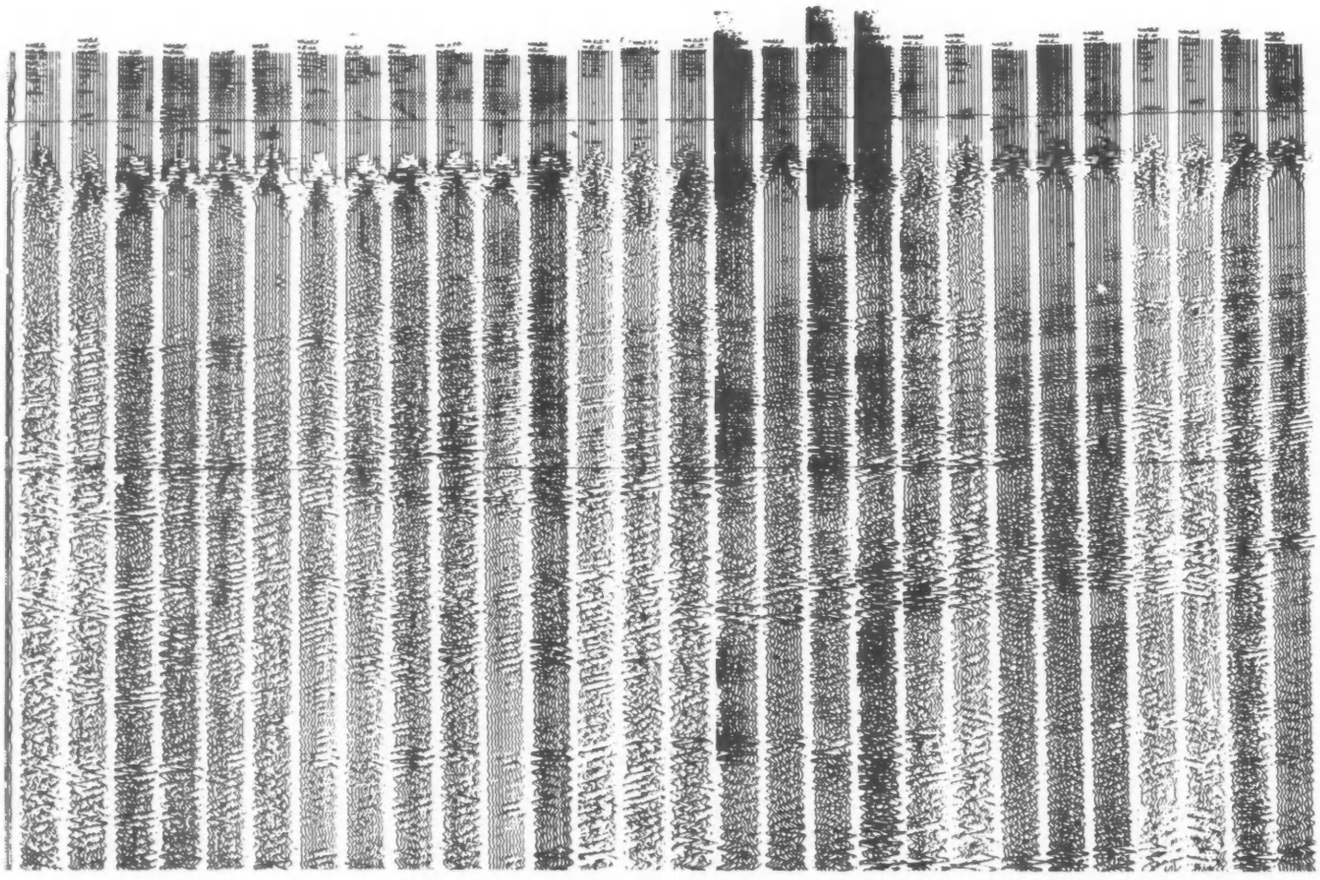

FIGURE 5—Record section made with a dynamic head shifter. Original recording was made on magnetic tape in South Texas.

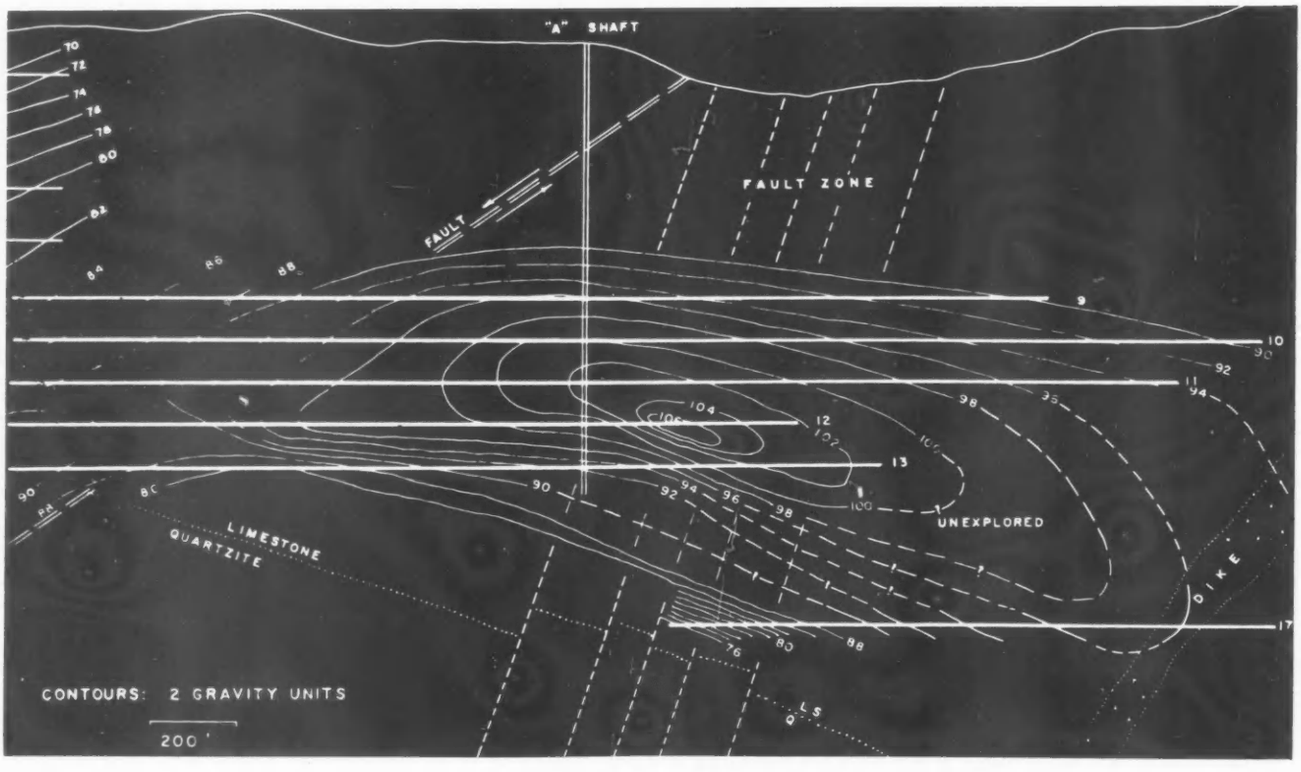

FIGURE 6—Vertical gravity map made in a copper mine near Bisbee, Arizona. Published by permission of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

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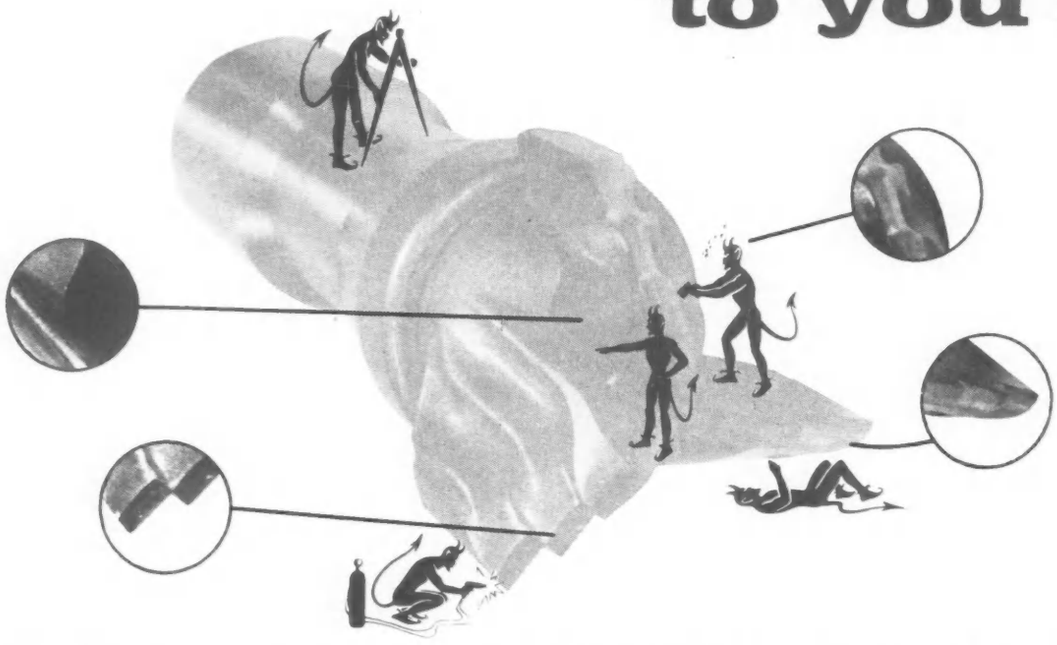

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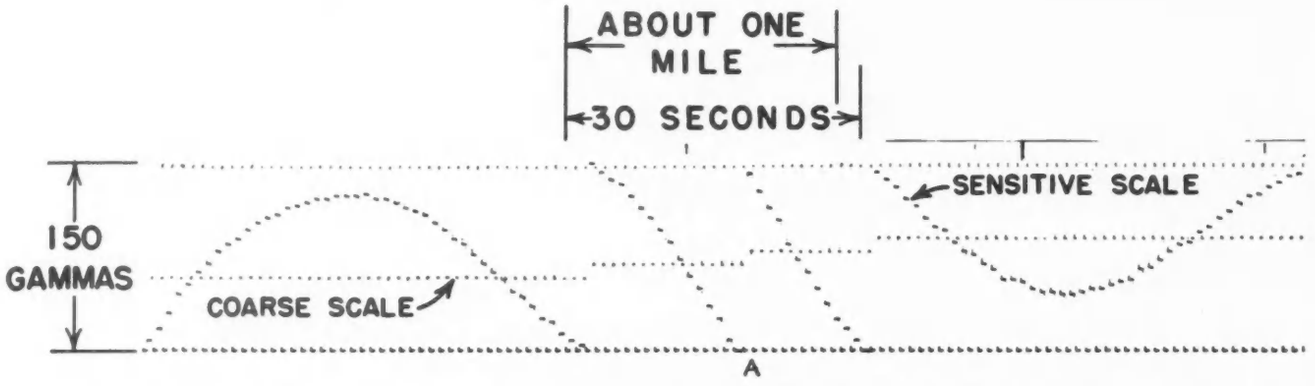


FIGURE 7—Sample record of the airborne magnetometer using nuclear magnetic resonance. Energizing current is applied for one-half second and output is measured for next half-second, resulting in closely spaced but discontinuous signals on record.

could be correlated only with great difficulty.

Another oil company is experimenting with record sections on variable density film. These should look more like geological-cross sections than any which use the conventional type of presentation.

Other seismic developments. Several other important developments in seismic prospecting should be mentioned. The thumper, which generates seismic energy by dropping a 3-ton weight on the earth, has seen increasing use during the past year. At least seven thumper crews are now in operation. Because of the large amount of magnetic tape required for recording the many individual drops that are composited to make up each final record, thumper operations are said to use up more than half of all such tape that is manufactured. Recently the system has gone to sea. The weight has been dropped on the surface of the water in Galveston Bay and, according to reports, has given good records there.

Because of an increase in reconnaissance-type exploration during the past year or so, there has been a resurgence of activity in refraction prospecting. One contractor has six refraction crews in operation, mostly outside the U. S. This work is carried on with a new geophone and recording system that make it possible to go to frequencies as low as 2 cps.

Gravity, magnetic, and electrical prospecting. In gravity prospecting, new developments have not been as numerous over the past year as in the seismic field. A new and improved model of the gamma-gamma density logger has been constructed and the data it gives appear to be adequate generally for gravity interpretation but not for porosity determination. Evaluation of this tool by a number of oil companies is continuing on a cooperative basis. Meanwhile it is being used operationally in many areas to get density data for gravity work.

Last winter, the first gravity contour map to have been constructed in a vertical plane was presented at the annual convention of the AIME in Chicago. Data for this map, which is shown in Figure 6, were obtained in the shafts and adits of a copper mine near Bisbee, Ariz. The pronounced high-gravity axis is shown to project into the unexplored area, suggesting the direction that further development of the mine property should take.

In magnetic prospecting, one development of the past year particularly worthy of mention. At the St. Louis meeting of the SEG in April, 1954, a new type magnetometer based on nuclear magnetic resonance was described. This instrument could measure absolute earth fields in the laboratory with an accuracy of one gamma. Within the past few months, this magnetometer has been adapted for operation in a light airplane and is now being used in actual surveys for iron ore in northern California. Installation consists of a small bird towed at the end of an 80-foot cable. The bird contains only a magnetic coil and a 1-liter bottle of water.

Figure 7 shows a sample record made with this device. Readings are recorded once a second, and the full-scale sensitivity of 150 gammas gives data quite comparable to what can be obtained from fluxgate-type magnetometers.

In electrical prospecting, most noteworthy trend of the past year has been a rapid increase in number of airborne electromagnetic surveys for base-metals. Two contract companies have been offering this service, and at least two mining companies have been making electromagnetic surveys from their own planes.

Promising advances have been made in electrical exploration for ground water by Prof. Vacquier of the New Mexico Institute of Mining and Technology, who has developed an induced polarization method for this purpose. His technique seems particularly suitable for determining depth of the water table in desert areas.

Fundamental studies. In the foregoing discussion, limitations of space have prevented the review of important fundamental research going on in geophysics at universities, in government instititions, and in endowed laboratories. Some of this work may well lead to improvements in exploration techniques. The principle of nuclear magnetic resonance, for example, was discovered in university laboratories only a few years ago and already it is being used in search for iron ore.

Some of the geophysical research at academic institutions is being supported by the oil industry. One example is the work of the Geophysical Analysis Group at MIT which is investigating statistical techniques for improving seismic reflection data.

Dr. Dorbin was with Magnolia Petroleum Company at the presentation date of this paper. However, he is now with the Triad Oil Company in Calgary, Canada.

ACKNOWLEDGMENT

This work was sponsored by a Special Committee on Research of the Society of Exploration Geophysicists and was presented before the society at its annual meeting in Denver, October, 1955. A somewhat different version was presented by Van Nostrand before the European Association of Exploration Geophysicists at its meeting in London in December, 1955. The complete paper appeared in the January issue of the Society's journal, *Geophysics*. However, by popular request from our readers, and with permission from *Geophysics*, a simplified, condensed version of the work is being published in World Oil so that those actively engaged in the fields of drilling and production will have the opportunity to become better acquainted with progress in geophysics.

Here geophysical tape is being slit into four-inch widths. It is estimated that some 140 geophysical crews are now equipped with some type of tape recording equipment. A vast expansion is predicted in 1956.

Magnetic Tape Recorder Spells Progress

To the exploration geophysicist this is a step in the direction of uncovering the vast quantities of undiscovered oil in world.

By R. E. SALTER
Geophysical Representative, ORRadio Industries

SCIENTISTS IN THE field of petroleum exploration estimate that 40 to 50 billion barrels of oil are yet to be discovered in the U. S. and an estimated 400 billion barrels are yet to be discovered in the rest of the world. New methods and instruments will be needed. And the introduction of the magnetic tape recorder is one step in this direction.

The use of magnetic tape by geophysical companies is pyramiding to a leading American industry, yet research and development in the techniques of magnetic tape recording and manufacturing is a never ending process.

Tape recording of music has been highly developed since the war, and it is now possible to make recordings of excellent quality and dynamic

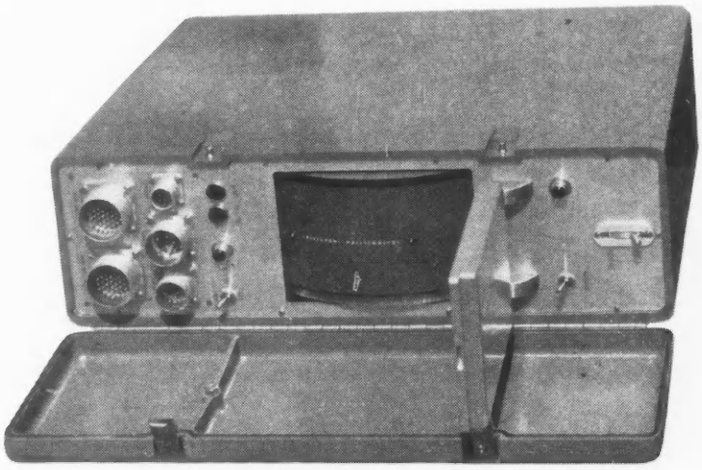
range. Between 1946 and 1950 tape recorders were also designed for the recording of physical data for vibration and strain analysis on aircraft. Multi-channel recordings were made on tape. In recording data where the amplitude of the reproduced signal was significant, and re-recording from the tape on a photographic record was desired. The mere magnitizing of tape according to the incoming signal was unsatisfactory. If it was desired to examine each cycle minutely, and to look at wave shape and amplitudes of transients, this technique for recording sound was limited by the tape not being absolutely uniform. Passing the same current through the recording head each time did not guarantee the same play-back voltage. This was due to the tape having differences in magnetic properties from point to point or variations in the thickness of the coating on the tape.

To improve data recording, instrument concerns designed other methods of recording. They tried to use a carrier frequency which was modulated so that the amplitude of the playback was not important. They developed the frequency modulated technique which removed the burden of fidelity reproduction entirely from the tape and placed it on the precision of the machinery drive system. The result was satisfactory and specific amplitudes could be read to accuracies in the order of one percent.

This equipment was not intended originally for geophysical use, but some of the seismic companies seeking improvements purchased and adapted it for seismic use. It was generally twelve channel equipment and recorded on tape about one inch wide. Sound on film was also tried, but the difficult recording and processing procedure as well as errors inherent to the system made it impractical. Tape had the advantage of few moving parts and a simple recording process.

In geophysics, the most important functions are time and phase, and the exact amplitude is not too critical.

In recording a seismic signal on tape the characteristics of the tape transport (recording-in and playing-out of the signal) represents a filter and subjects the signal to phase shifts and time delays which are undesirable. The geophysical signal is filtered anyway and goes through phase shifting and time delaying devices such as



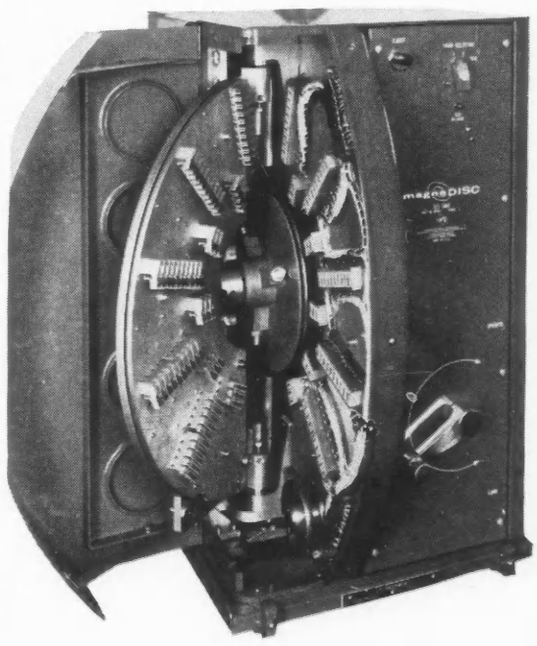
PORTABLE RECORDER A new item recently introduced is the portable recorder. This recorder was developed as a light weight, simple to operate system for recording seismic data in the field. It is a direct FM recorder.

Twenty-four data channels and four information channels are provided to record signals from the output and four information channels are provided to record signals from the output of geophysical amplifiers. These signals vary the magnetic density in a layer of iron oxide on a recording tape to give permanent records of shot data. The unit uses a standard 14-inch tape transport drum. Recordings made on this portable machine can thus be reproduced on more elaborate playback and analysis equipment. The information signals can be used to make any number of oscillographic records. Records from different shot depths can be composited.

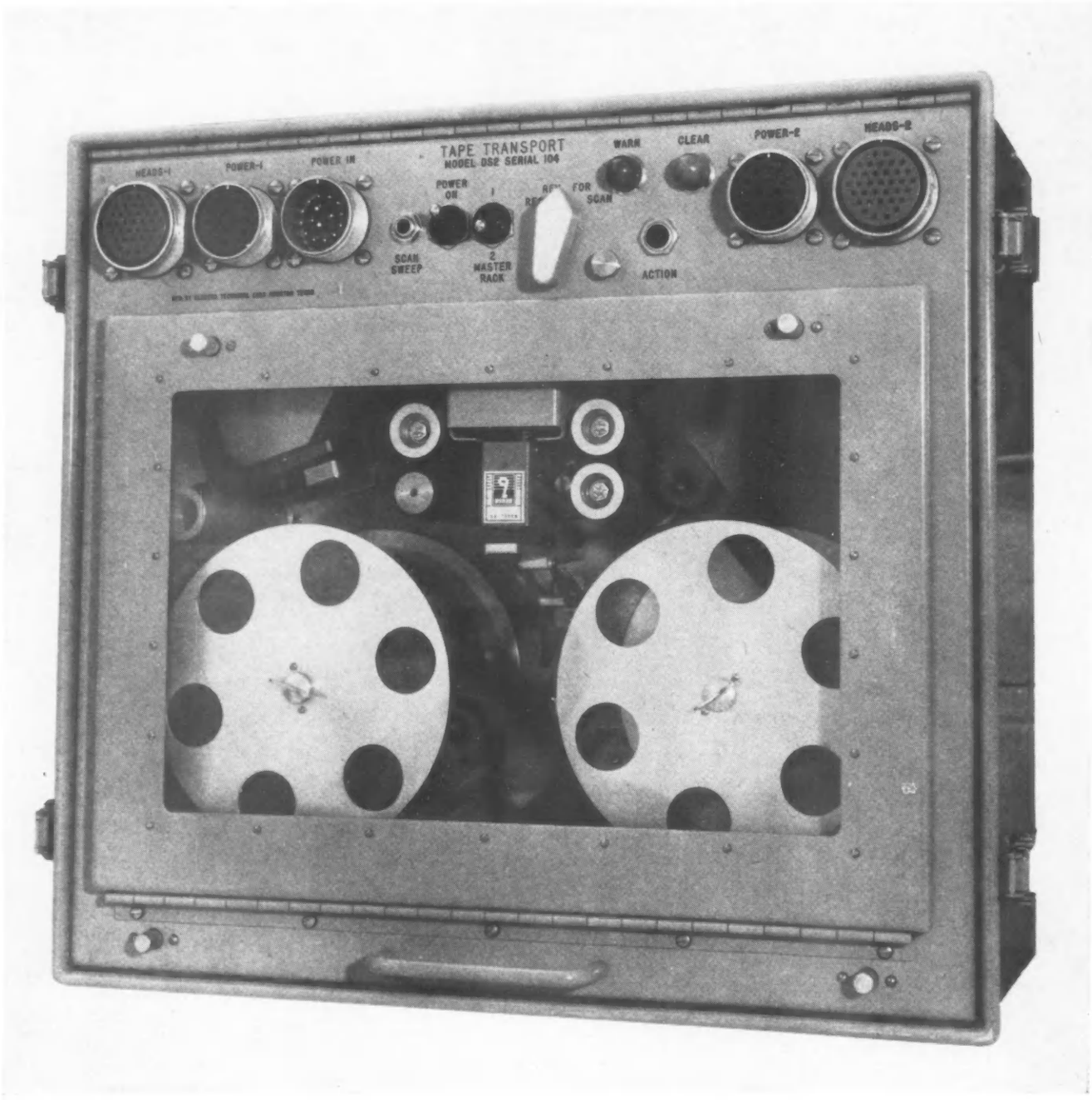
The tape transport drum is rim driven through a gear train by a hysteresis synchronour motor. A nylor gear is employed in the system to prevent gear tooth engagement noise from interfering with the information signals. A non-resonant vibrator provides the constant 60 cps source for accurately controlling the speed of the transport drive. Recording heads are mounted in two banks of 14 each and are individually suspended. Heads can be readily adjusted to obtain correct pressure on the tape and for tracking accuracy.

The recorder case is constructed of ribbed magnesium alloy with only one access cover for loading tape and admittance to electrical connections. All connections and controls are accessible from the front panel. When the cover is closed the unit is sealed and meets specifications for water resistant sealing. Only droplet penetration during a five minute immersion would be expected.

DISC TYPE RECORDER Here is a seismic magnetic recording system utilizing a plastic disc as the recording medium. This unit is an FM system for use with conventional seismic amplifiers and oscillograph. It consists of a separate transducer unit, electronics case, and power supply pack.



It records the full seismic frequency spectrum in one broad band shot. Electrical signals are transmitted to the iron oxide coating of a plastic disc, and may be played back immediately to conventional photographic records utilizing any desired filter or AGS setting in the seismic system. Or a conventional recording may be made simultaneously with the disc recording. A playback from the discs using the same instrument settings will reveal no difference in the quality of the two records. These monitor records permit immediate evaluation of optimum equipment settings, yet all vital seismic information is permanently stored on the disc for unlimited analysis at a later time.



MAGNETIC RECORDER-REPRODUCER

The above unit consists of two basic packages, the tape transport and the modulator-demodulator units, each weighing 40 pounds. The equipment is designed for use with conventional seismic amplifiers and recording oscillographs.

The input signal is pulse width modulated before it is applied to the recording heads. The carrier frequency is 1600 cycles per second. The tape transport is of the spool type in which the tape is pulled across 28 recording heads at 15 inches per second. In this manner recordings may be made in rapid succession, an important asset in offshore shooting.

The demodulator unit has two outputs, one of which is capable of driving galvanometers without further amplification. Thus, it is possible to play back a shot and obtain both a filtered record and a broad band record simultaneously.

the geophone, seismic amplifier, and galvanometers on the recording oscillograph. However, if it is desired to make records where a series of recordings with the same geophone spread and different shots are taken and to later composite these in laboratories with direct recording, we need a machine with as many playback tracks as there are recordings. This compositing method places the seismic wave forms in phase, to the degree that the final record reveals a more definite and amplified relationship to the original individual channel recording, thereby revealing the true area formations for precise interpretations.

Most geophysical recording instruments now have between 24 and 48 channels for recording data. Highly complex analysis and playback machines are being developed. It is estimated that there are about 140 geophysical crews equipped with some type of tape recording equipment. In 1956 a vast expansion is expected and

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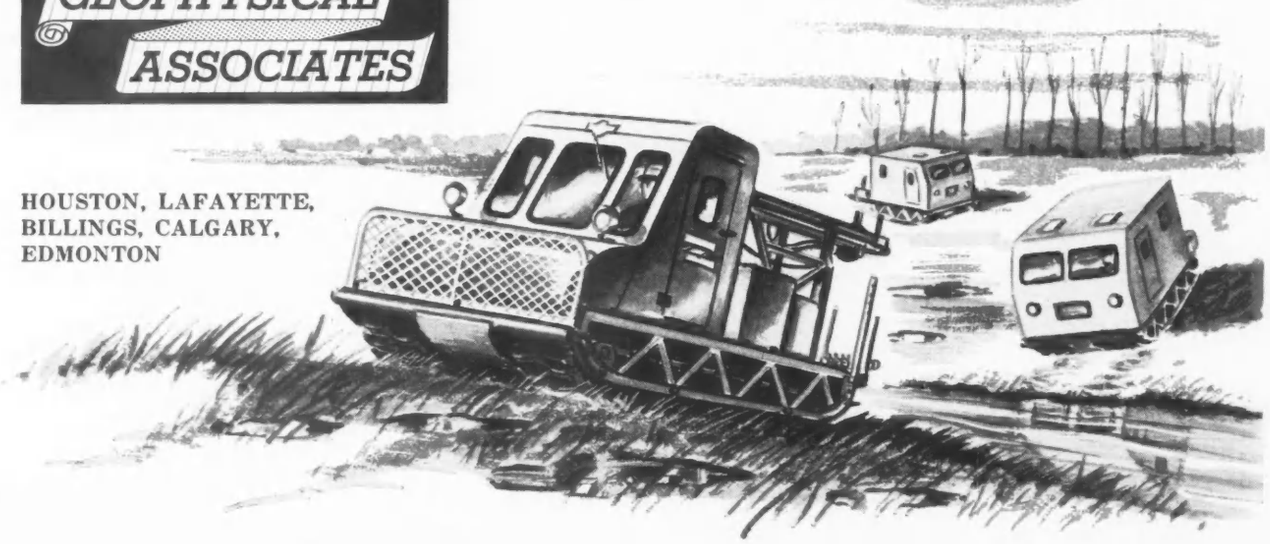
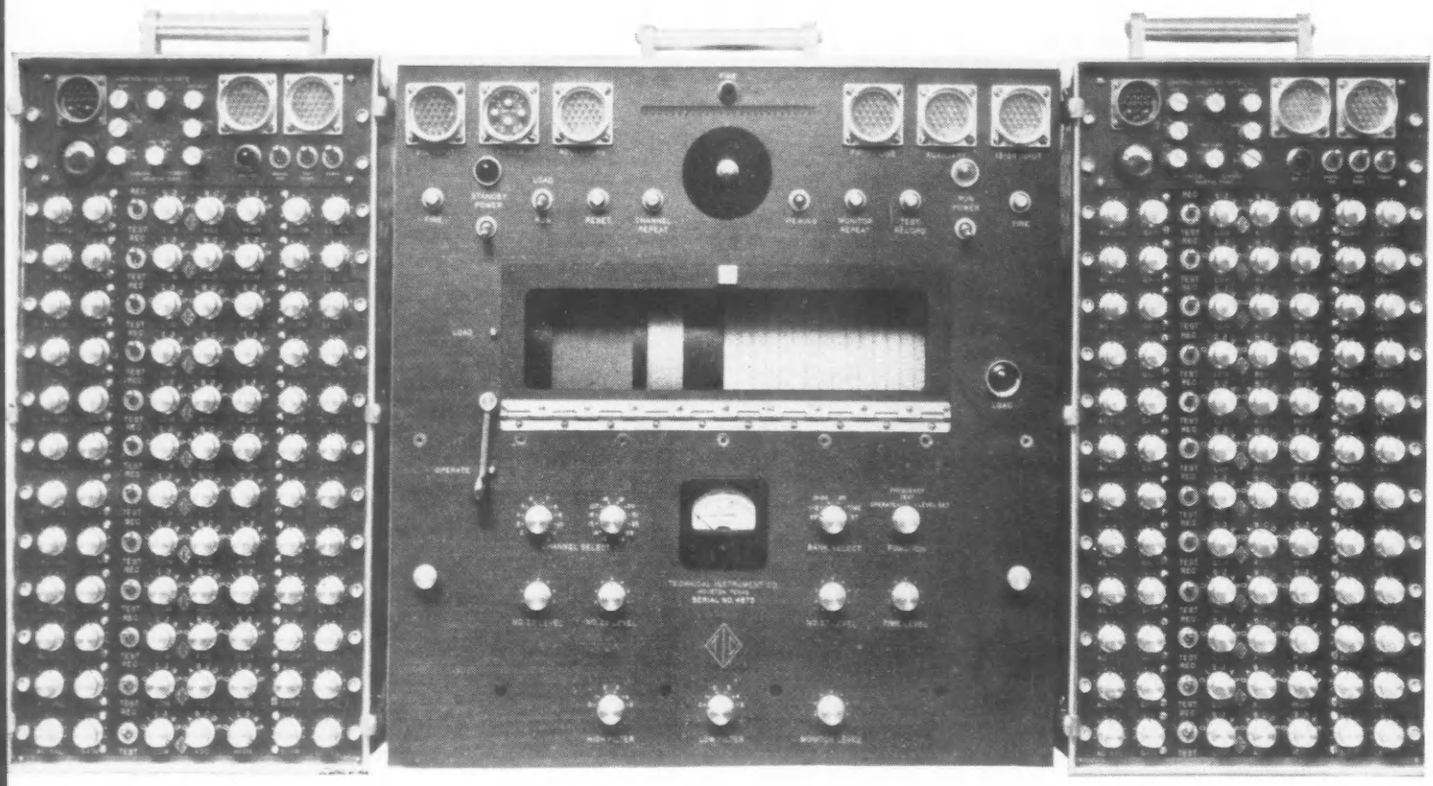




FIELD RECORDER-MONITOR This field recorder is designed specifically for truck mounting, but can be mounted in boats or other conveyances. The truck system normally includes: two banks of 12 modulator-amplifier special wide band magnetic recording amplifiers with integral modulators, and control panel; the 28 channel tape recorder magnetic recorder, complete with 25 channel galvanometer style viewing system, 28 channel permanent record monitor system, 4 modulators for extra information channels, and a monitor de-modulator and amplifier with built-in high and low cut filters; and the power supply and time standard for the magnetic recorder.

The modulator-amplifiers take the signals directly from the geophones, apply full AGC and some soft filtering, and frequency modulate these signals for recording on the tape.

The recording equipment is a magnetic drum recorder capable of recording simultaneously 28 channels of seismic information on magnetic tape for a period of five seconds. The linear velocity of the tape is 7.5 inches per second.

The magnetic recording process employs an FM carrier of 4500 cps, which is deviated plus or minus 1800 cps. Information in the range of 10 cps to 500 cps is recorded subject to the soft filtering which can be done in the amplifier modulator as previously described.

A tuning fork time standard and servo-control of drum speed is included as part of the equipment. The 50 cycles derived from the tuning fork is both recorded on the magnetic tape as a reference channel for further synchronizing use.

tape recording will probably become almost universally used in seismic data recording.

There are several schools of thought on tape recording technique. The most idealized is to obtain a record of as high fidelity as possible by recording with maximum frequency limits and dynamic range, capturing the signal exactly as it emerges from the ground.

How It Came About. The medium of magnetic tape recording has developed from its first discovery to the present level in less than 10 years.

Shortly after D-Day during World War II, American Commandos captured Radio Luxembourg almost intact. Maj. J. Herbert Orr, Chief Engineer, Radio Division, S.H.E.A.F. discovered 3 German "Magnetophones" at the radio station.

They were Hitler's prized possessions. Although originally patented in July, 1921, according to records of the German patent office, the secret had been well guarded, before and during Hitler's rise to power.

Major Orr learned through intelligence that an aged scientist, Dr. Karl Pflumer was responsible for the magnetophone's existence, and Dr. Pflumer lived in Ludwigschaffen near the Luxembourg border.

A visit was paid Dr. Pflumer by Major Orr, who had encountered some difficulty in obtaining magnetic tape for the magnetophones, the problem was stated to Dr. Pflumer, and after a few moments silence he answered in perfect English, "Yes I will give you the formula for producing magnetic tape, it will not be the best method, but the simplest, since you need it very quickly."

With the information furnished Major Orr returned to the radio station and within two weeks was producing magnetic tape to record Gen. Dwight D. Eisenhower's messages.

An automobile accident disabled Major Orr, and after months in hospital, preparations were made to send the major back home. To his surprise, the aged German scientist walked up to the litter bearing the major from the ambulance to the transport, Dr. Pflumer knelt beside the litter, taking an envelope from his pocket saying "As a token of my esteem for you" then he was gone.

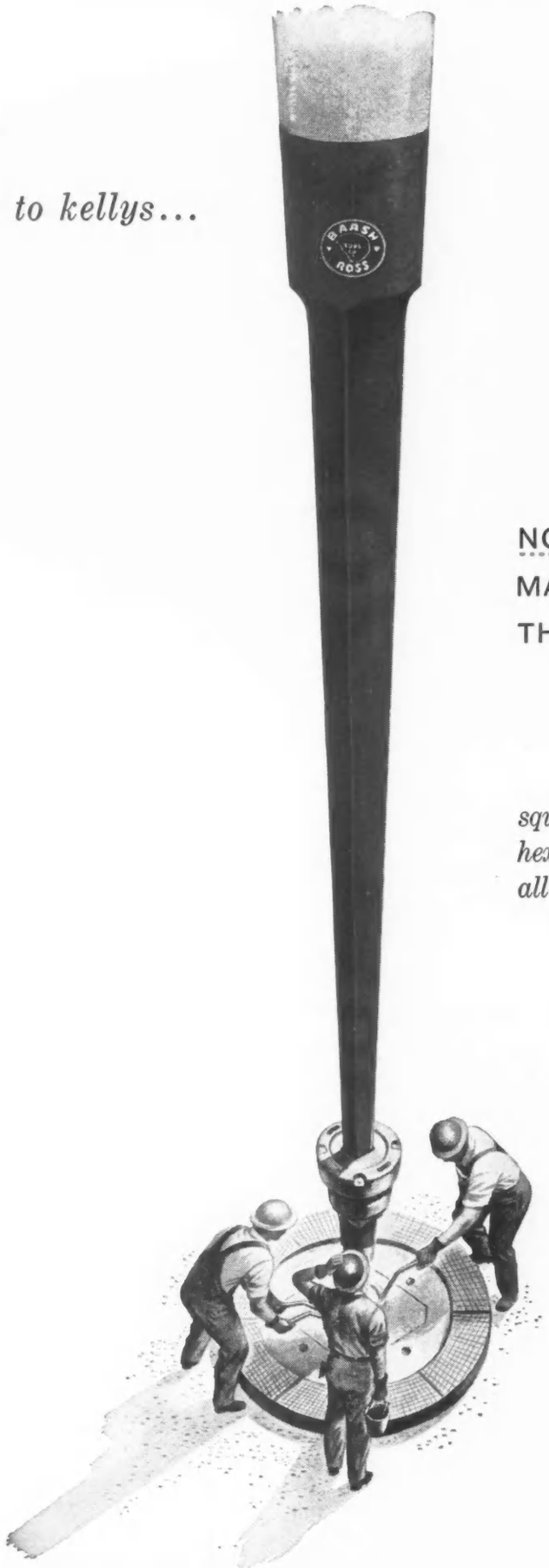
This envelope contained Dr. Pflumers formulae and findings on how to make top quality tape.

In 1946 Orr assembled the first tape recorder, and demonstrated it at the annual convention of American Radio Broadcasters. It was at this time that an American industry was born.

ACKNOWLEDGMENT

The author is indebted to Houston Technical Laboratories, Electro-Technical Laboratories, Southwestern Industrial Electronics and Technical Instrument Company for the photographs and equipment description accompanying this article.

when it comes to kellys...



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Weight-Drop Technique— How It's Working Out

Three years of field experience with this new seismic method have uncovered some definite advantages. Now a barge unit is being built to carry the method into marine operations.

In June, 1954, WORLD OIL published the article "A New Approach to Seismic Exploration" by R. L. Palmer, Executive Vice President of the McCollum Exploration Company. This article introduced the then new technique of weight dropping. Since that time, the development of this technique has been improved while considerably more field data are available for inspection and evaluation. This second article describes the historical background of the technique along with the latest developments and results to date.

By ALAN D. WALDIE
McCollum Exploration Company, Houston

THREE YEARS experience in commercial operation of the weight dropping technique show that the principles involved in the system, though still in the process of compete development, have opened up many new avenues of progress toward improving record quality, while reducing the over-all cost per profile mile of geophysical field production. The technique is a culmination of over 15 years of research and development in devising a method to obtain better seismic records in hard rock areas at a lower cost per profile mile.

Several months ago experiments were conducted in Galveston Bay to test the feasibility of using the weight dropping technique on offshore operations. As a result of these tests, a crew is now being outfitted under contract to perform geophysical water work from a 25 foot by 60 foot barge.

Figure 1 shows a special barge being constructed to accommodate the weight dropping mechanism and recording instruments. The weight will be dropped through the well shown in center of the barge.

It has been a well known fact that for many years surface and near-surface hard rock areas, as in the Edwards Plateau of West Texas, the Anadarko Basin of Oklahoma, parts of Southern Alabama, and possibly portions of Florida, have posed many problems in obtaining usable seismic reflections. These problems were due mainly to horizontal energy, created

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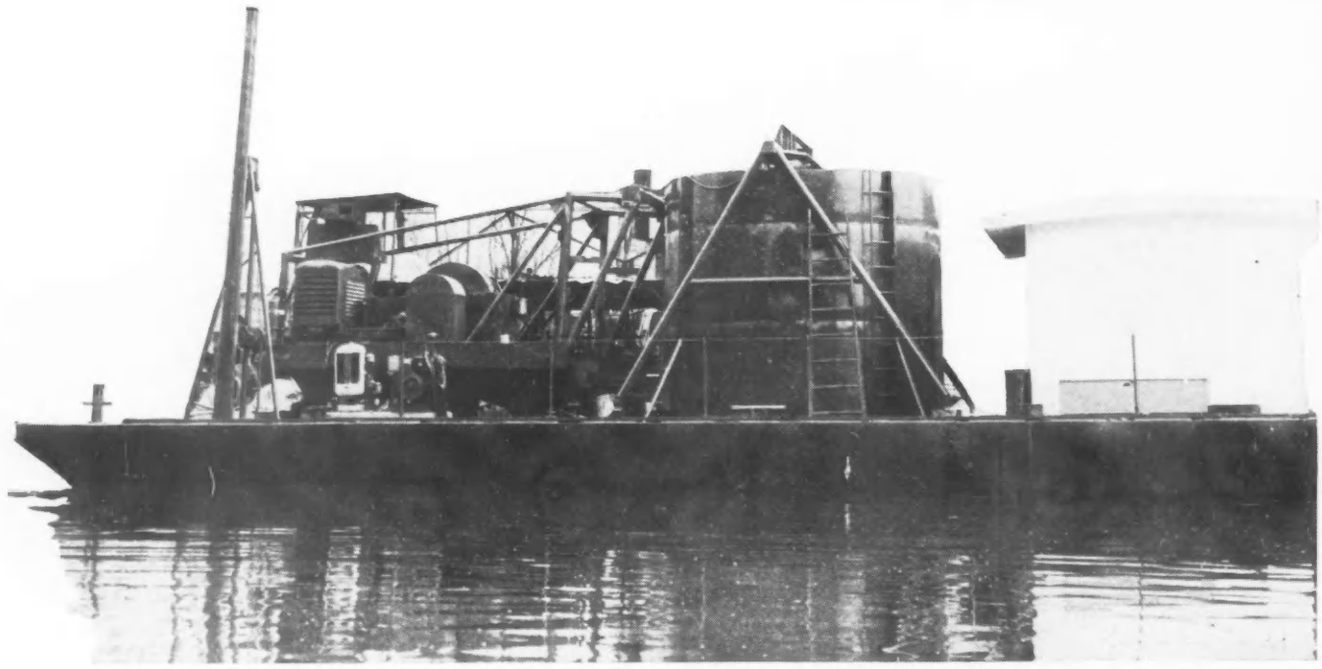


FIGURE 1—Special barge being constructed for water operations. Weight will be dropped through well in center of barge.

Field instruments in panel truck. Operator loads on a new magnetic tape for recording.

by dynamite shothole blasts, or fissured, faulted, cavernous limestone rock found near the surface of the ground. The sustained complex horizontally traveling reverberations created would tend to obscure, or completely obliterate, the desired vertical energy.

Another reason for poor seismic interpretations in some of these areas is due to the cavernous conditions of limestone below the surface. The near-surface caverns often absorb nearly all of the vertical energy from a charge of dynamite and at the same time act as reflecting sources to increase the horizontal waves. These problems, along with those found in some areas which contain complicated conditions of reefs, unconformities, inconsistency of stratigraphic units over a great distance, lenses and lithologic changes which occur in relatively short distances, all sum up to one "terrific headache" to those computers and geophysicists who have had the task of interpreting seismograph data obtained in these areas.

For several years these difficulties have been remedied somewhat by the use of multiple detectors and shotholes dispersed in a manner of pattern shooting to introduce phase shifts between vertical and horizontal traveling energies. The resulting phase shifts partially cancel the undesirable horizontal energy and reinforce the desired vertically traveling waves. Some form of pattern shoot-

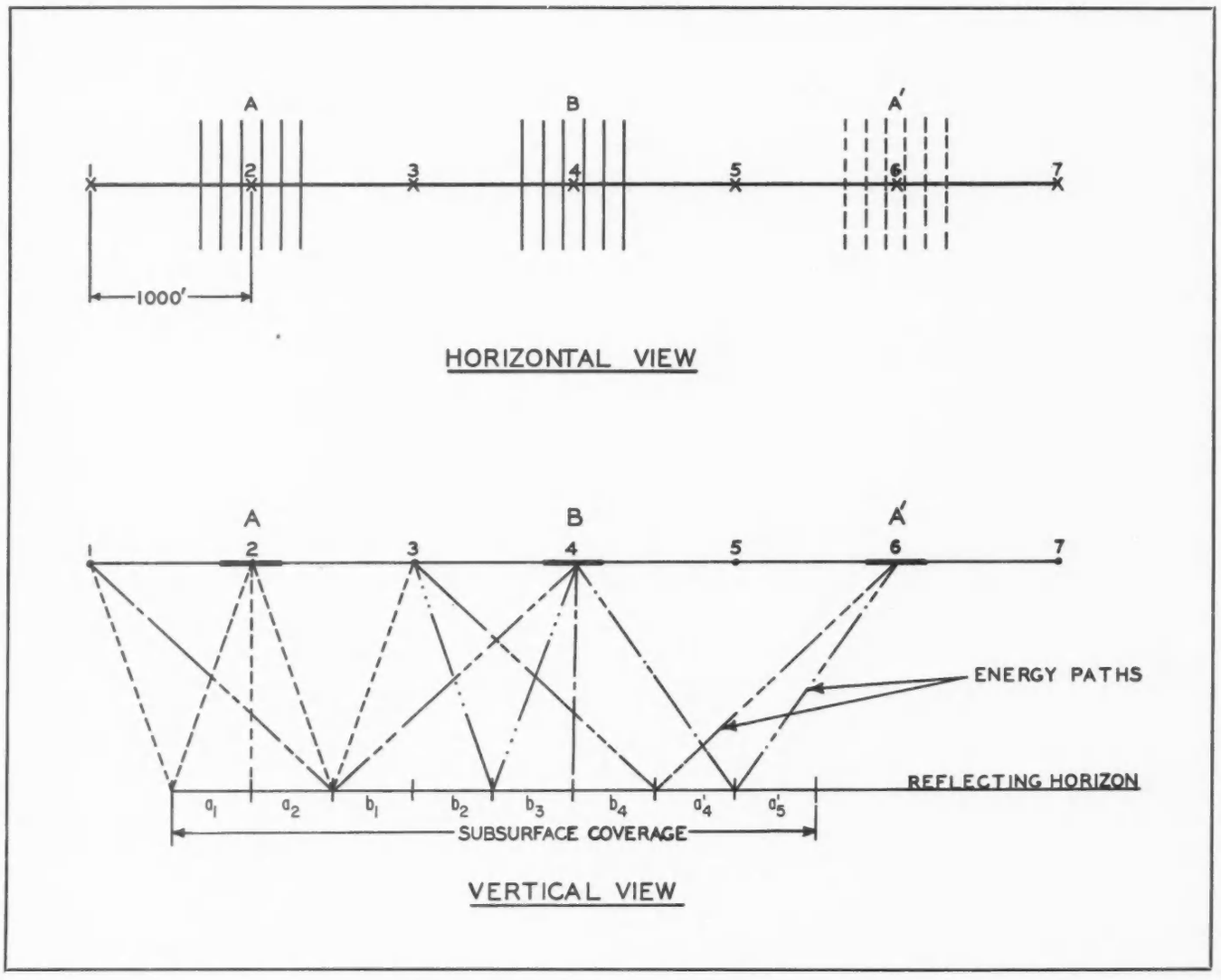


FIGURE 2—Weight-dropping field procedure.

About the Author

ALAN D. WALDIE, chief engineer for McCollum Exploration Company, Houston, was graduated from Texas A. & M. College in 1951 with a B.S. degree in electrical engineering. After two years as a U. S. Army Signal Corps officer he joined McCollum in 1953. Waldie is a member of the SEG and IRE.

ing has been used in these areas for the past few years. It usually consists of 20 to 40 shotholes drilled in a pattern to each shotpoint along with a combination of 10 to 30 detectors per detector station.

To accomplish any worthwhile production with the above shooting method in hard rock areas, from 3 to 5 drilling units on each crew are required. Drilling costs alone often represent the major part of the cost of crew operations in such areas.

The development of the weight dropping technique was primarily geared toward the improvement of seismic records in hard rock areas and the subsequent elimination of shothole drilling entirely. The basic idea of the weight dropping technique is to use a method of generating an impact that can be very cheaply and rapidly dispersed over a wide area.

The weight dropping truck consists of hoisting and releasing mechanisms which raise a three-ton slab of steel, measuring 3 feet and 5 feet by 8 inches thick, approximately 9 feet above the ground and release this weight for a virtual free-fall to the ground. It may be of interest to note that the power set up by the weight impact of a 9-foot fall is equal to about one-half ounce of 60 percent gelatin dynamite. However, the elastic energy set up by the falling weight is very large as compared to a dynamite blast of the same energy.

It has been proven that sufficient energy is generated by the weight drop to get a reflection down to the base of the Ellenburger formation or deeper. The weight dropping technique, to be most effective, should produce a signal from successive impacts of uniform amplitude.

It should be pointed out that the mere dropping of a three-ton weight

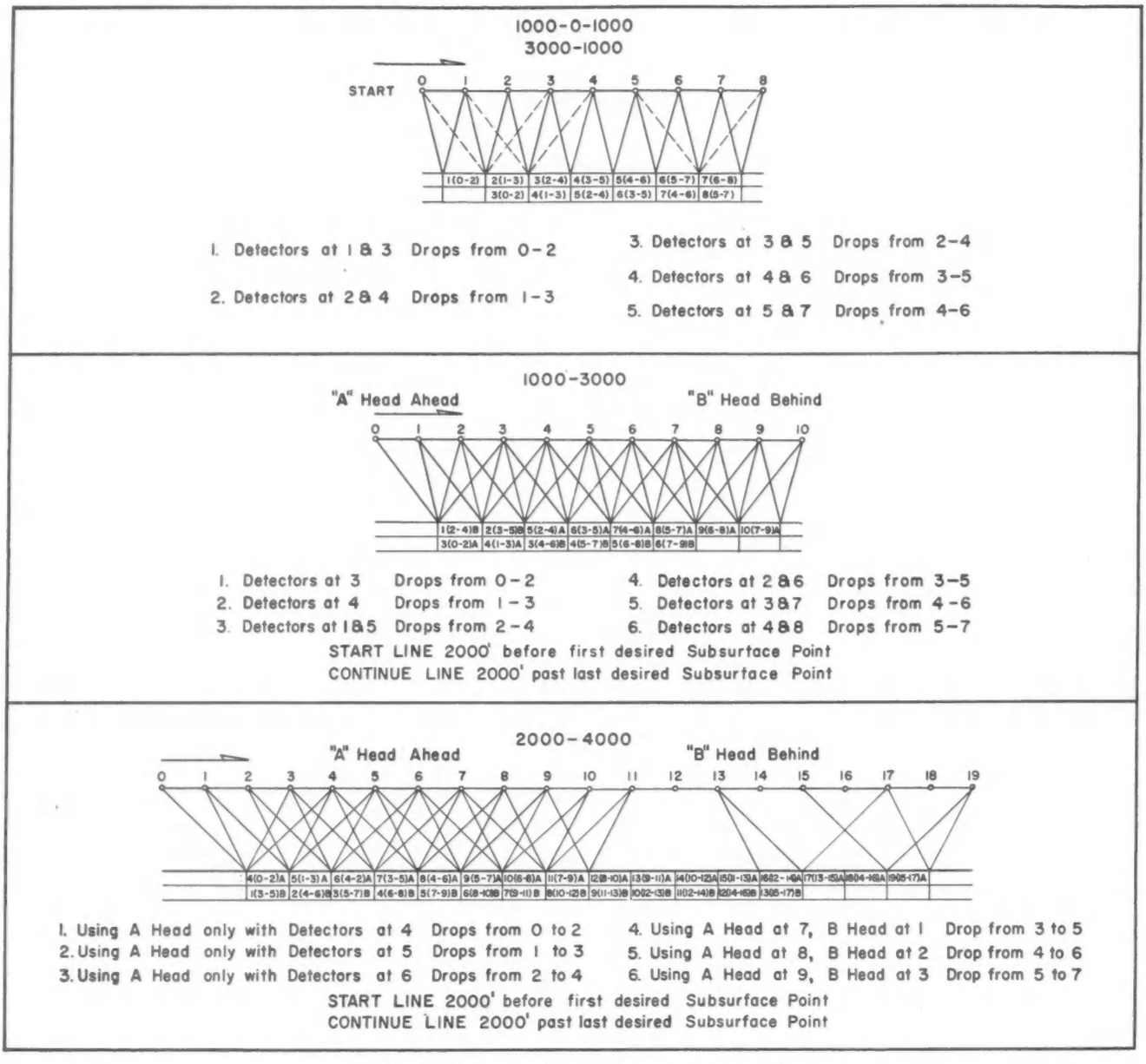

1000-0-1000
3000-1000
START
0 1 2 3 4 5 6 7 8
1(0-2) 2(1-3) 3(2-4) 4(3-5) 5(4-6) 6(5-7) 7(6-8)
3(0-2) 4(1-3) 5(2-4) 6(3-5) 7(4-6) 8(5-7)
1. Detectors at 1 & 3 Drops from 0-2
2. Detectors at 2 & 4 Drops from 1-3
3. Detectors at 3 & 5 Drops from 2-4
4. Detectors at 4 & 6 Drops from 3-5
5. Detectors at 5 & 7 Drops from 4-6
1000-3000
"A" Head Ahead
"B" Head Behind
0 1 2 3 4 5 6 7 8 9 10
1(2-4)B 2(3-5)B 5(2-4)A 6(3-5)A 7(4-6)A 8(5-7)A 9(6-8)A 10(7-9)A
3(0-2)A 4(1-3)A 5(4-6)B 4(5-7)B 5(6-8)B 6(7-9B
1. Detectors at 3 Drops from 0-2
2. Detectors at 4 Drops from 1-3
3. Detectors at 1&5 Drops from 2-4
4. Detectors at 2&6 Drops from 3-5
5. Detectors at 3&7 Drops from 4-6
6. Detectors at 4&8 Drops from 5-7
START LINE 2000' before first desired Subsurface Point
CONTINUE LINE 2000' past last desired Subsurface Point
2000-4000
"A" Head Ahead
"B" Head Behind
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
4(0-2)A 5(1-3)A 6(4-2)A 7(3-5)A 8(4-6)A 9(5-7)A 10(6-8)A 11(7-9)A 12(8-10)A 13(9-11)A 14(10-12)A 15(11-13)A 16(12-14)A 17(13-15)A 18(14-16)A 19(15-17)A
1(3-5)B 2(4-6)B 3(5-7)B 4(6-8)B 5(7-9)B 6(8-10)B 7(9-11)B 8(10-12)B 9(11-13)B 10(12-14)B 11(12-14)B 12(14-16)B 13(15-17)B
1. Using A Head only with Detectors at 4 Drops from 0 to 2
2. Using A Head only with Detectors at 5 Drops from 1 to 3
3. Using A Head only with Detectors at 6 Drops from 2 to 4
4. Using A Head at 7, B Head at 1 Drop from 3 to 5
5. Using A Head at 8, B Head at 2 Drop from 4 to 6
6. Using A Head at 9, B Head at 3 Drop from 5 to 7
START LINE 2000' before first desired Subsurface Point
CONTINUE LINE 2000' past last desired Subsurface Point

FIGURE 3—Field procedure—double coverage method.

nine feet to the ground, instead of shooting dynamite in hard rock areas, will not alone eliminate seismograph interpretation problems in the areas mentioned above. The heart of the entire weight dropping technique is an integrating FM magnetic tape recorder system. One part of the system is used in the field to magnetically record and correct drop time variations of the seismic energy generated by the weight drop and received by the geophones in the detector patch.

Another part of the system is used in the laboratory or field office, to process and analyze the magnetic taped field recordings and to produce tapes which have been corrected for variations of time-of-fall of the weight drops, elevation, weathering, and step-out variations.

The final part of the system consists of a laboratory, or regional field office, analyzer and integrator which composites or integrates the corrected tape recorded weight drops into a usable photographic seismogram for interpretation.

To understand more fully the various processing and integrating operations required in the weight dropping system, an explanation of field procedure should first be made. A typical weight dropping crew consists of a party chief, an instrument operator and assistant, a weight truck driver and operator, a surveyor and 1 or 2 assistants, a wireman and 4 to 6 detector patch men.

After the survey crew has laid out an area to be explored with the weight dropper, the weight truck is put into position on line for dropping. Drop intervals along the line depend on detector station intervals to be used in an area. Normally, 1000-foot or 1500-foot station intervals are used, which would place drop intervals at 21 or 31 feet respectively, along the line of survey to give a total of 96 drops per setup.

Figure 2 shows one field procedure which can be used with two detector patches spaced 2000 feet apart using a 1000-foot station interval and a 21-foot drop interval. Each patch consists of 36 geophones connected in a series-parallel arrangement to one geophysical amplifier per patch.

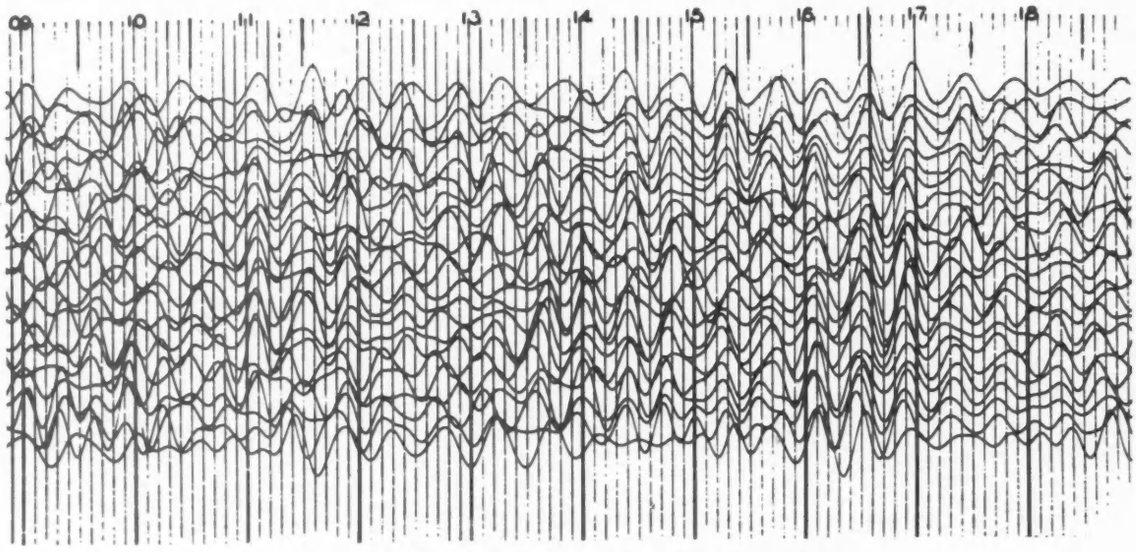


FIGURE 4a—Complete set-up composited four drops per trace.

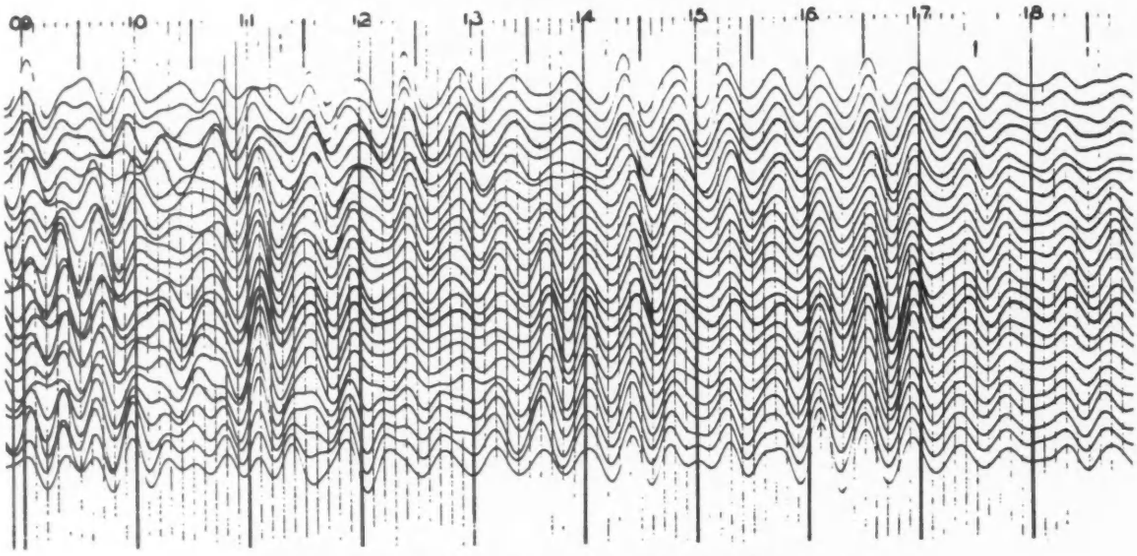


FIGURE 4b—Complete set-up composited twenty-four drops per trace.

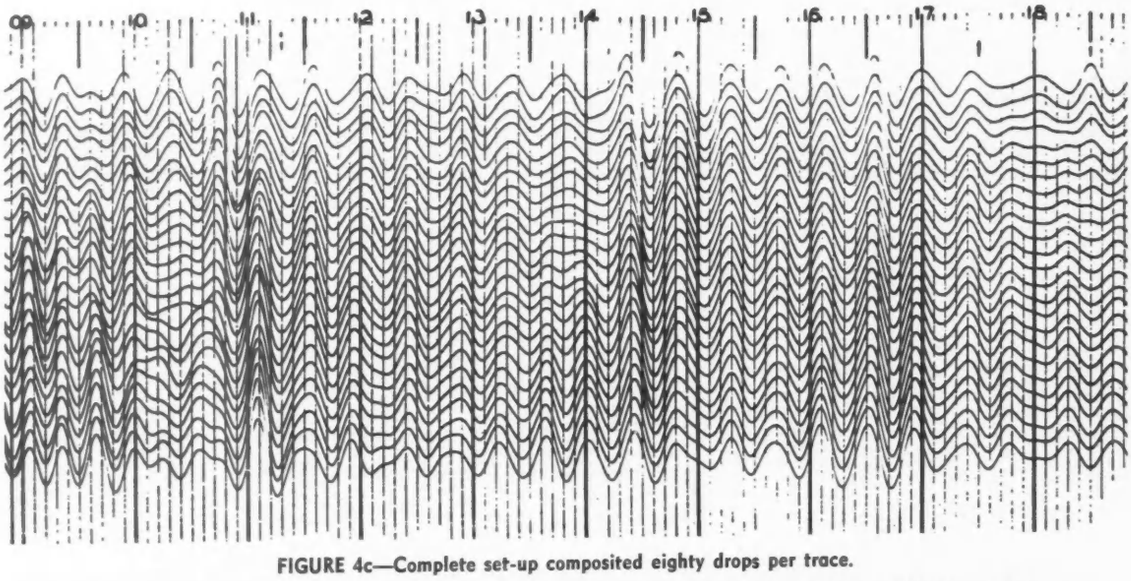


FIGURE 4c—Complete set-up composited eighty drops per trace.

WEIGHT-DROPPING RECORD INTEGRATION—WEST TEXAS AREA

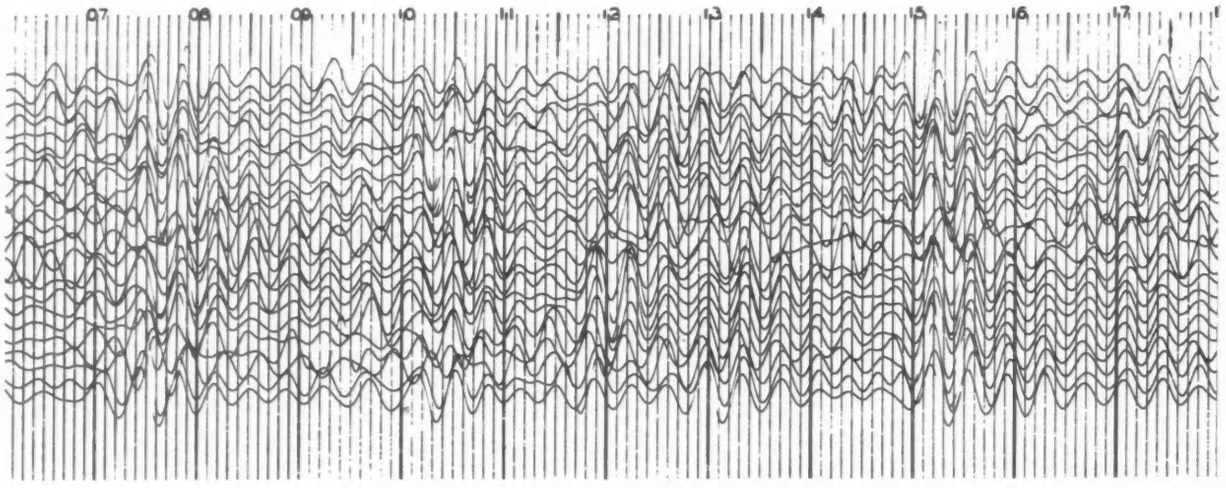


FIGURE 5a—Complete set-up composited four drops per trace.

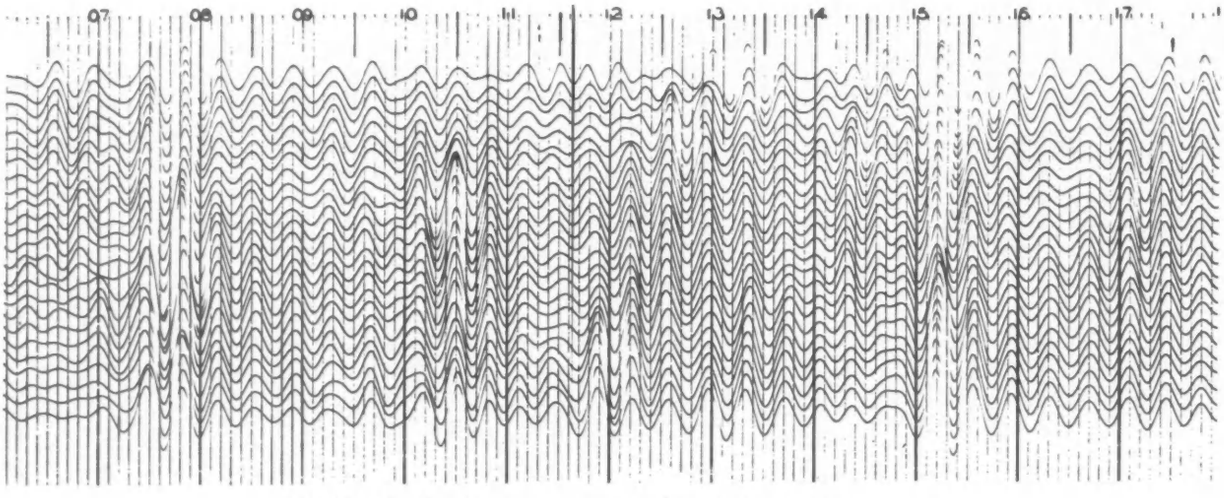


FIGURE 5b—Complete set-up composited twenty-four drops per trace.

WEIGHT-DROPPING INTEGRATION—GULF COAST AREA

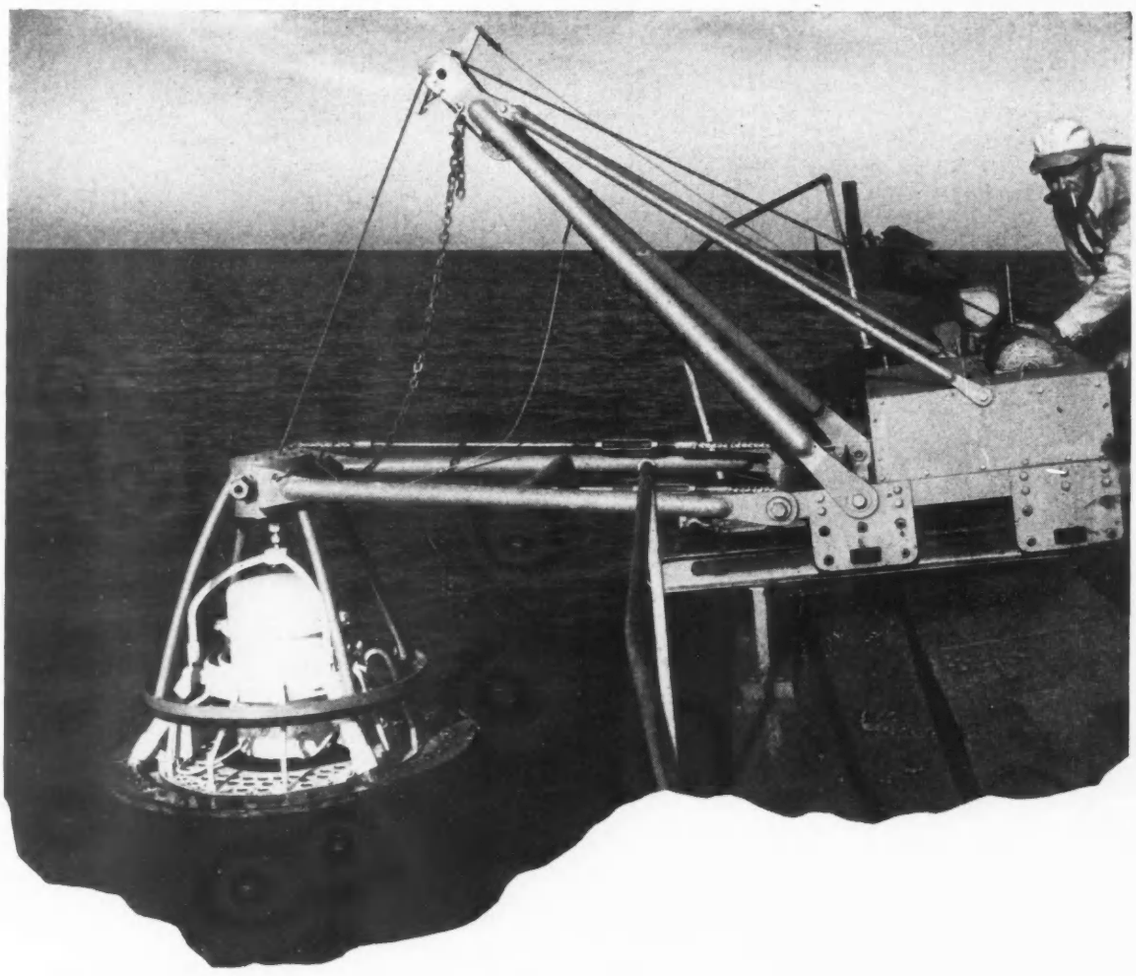
Patch A is placed on Station 2; Patch B is placed on Station 4. The weight truck starts at Station 1. As the weight truck moves in 21-foot intervals from Station 1 down the line, the weight is dropped by radio control from the recording truck in 12 to 16-second intervals. Two patches are used at a time in order to make subsurface coverage equal to drop coverage on the surface.

For example, as drops are made from Station 1 to Station 2, Patch A records subsurface a_1 and Patch B records b_1. From Station 2 to Station 3, Patch A records a_2, Patch B records b_2. Patch A′ is now connected in at Station 6 and Patch A is disconnected. Dropping from Station 3 to Station 4, Patch B records b_3 and Patch A′ records a'_4. From Station 4 to Station 5, Patch B records b_4 and Patch A′ records a'_5, etc. This process continues until the line under survey is completed.

There are several variations to field procedure used, depending upon existing conditions of the area to be surveyed. Through-the-Patch, or "split" spreads of 1000 feet-0-1000 feet, or 1500 feet-0-1500 feet are quite effective in many areas (Figure 3). In other areas, Extended-on-Line Spreads of 1000 feet to 3000 feet and 3000 feet to 1000 feet, 2000 to 4000 feet and 4000 to 2000 feet are more effective. Combinations of the "split" spread and Extended-on-Line Spread can also be used as shown in Figure 2.

Simultaneous magnetic tape recordings are made in the instrument truck of each drop return energy from each of two detector patches. These drops are sequentially stored on tape and automatically corrected for variations of time of fall of the weight. At the end of each day's work, the completed "raw" tapes are sent with data sheets to the laboratory, or local field office, for processing and integration.

The geometrical discrepancies in travel paths of energy from the various subsurface layers, known as step-out, or normal move-out, must be removed by the processing equipment to assure proper line-up of



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vertical energies for accurate integration. Since stepout corrections vary throughout the record with each vertical reflection, a dynamic correction must be applied according to the velocities of the record area. Electronic computers, incorporated in the equipment, accurately program the stepout corrections necessary throughout the record.

The actual time-of-fall of the weight to create an impact is variable due to:

- Variable release time.
- Variable friction in the release mechanism.
- Variable height of fall due to surface irregularities.
- Variations in the degree of compaction of the ground as a plowed field, etc.

All of these variables must be compensated for so that the vertically traveling energy will be recorded as though no variation in time-of-fall existed. In addition to stepout variations and time-of-fall differences, which are removed, it is desirable to remove time differences due to changes in elevation and weathering encountered along the "line of drops."

The elevation corrections are computed from the surveyor's notes and applied as static time correction along with weathering information received from velocity surveys of the area. A new method of determining continuous weathering control by the weight dropping technique has recently been developed after more than two years' research and field tests. It will shortly be offered to the industry as an additional weight dropping field service.

After all corrections mentioned above have been applied to the "raw" field tapes, a "corrected" tape is produced to be used in the process of integrating (compositing) the signals to attenuate the horizontal and low angle events and accentuate the time corrected reflected events. This results in a photographic seismogram, similar in appearance to "conventional" records, but different in that the events shown are generally cleaner and more defined than the older conventional style.

The integration process is accomplished by combining a number of the corrected single weight drops, usually 24 or more, into a single photographic trace. The number of drops to be combined depends upon the area under process. For example, in West Texas, at least 24 drops are composited per trace in order to reduce the undesirable horizontal energies, and to increase the vertical energies.

Figure 4a illustrates a set-up of 96 drops, composited of four drops per trace, from a "problem area" in West Texas. Figure 4b shows an integration of these drops to illustrate the improvement of integrating 24 drops per trace. However, Figure 4c shows still more improvement of the same set-up by integrating (80) drops per trace to give a much greater coverage per trace. In areas where extreme dips are not expected to be encountered, a large composite, as 96 drops per trace, can be used to clarify the subsurface conditions existing.

Gulf Coast conditions generally require much less integration of drops per trace to produce a clear, readable seismogram. Figure 5a illustrates a complete set-up of 4 weight drops composited per trace in a Gulf Coast area. Figure 5b shows an integration of 24 drops per trace of the same set-up.

To date, there are eight complete weight dropping field crews operating on a 50-hour week and producing an average daily production of 17,000 feet of subsurface per crew. It is not uncommon for a crew to obtain 35,000 feet of subsurface per day in an area where terrain permits full production speed. These crews have successfully operated in more than 25 counties in Texas, including Scurry, Reagan, Irion, Crockett, Schleicher, Edwards, Pecos, Sutton, Upton, Crane and Reeves and in several counties in New Mexico, Kansas, Florida and Mississippi.

—The End

For other articles relating to Exploration Progress, see the Current Outlook and International sections of this issue.

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Part 2 of "North Dakota's Nesson Anticline" by W. M. Laird and C. B. Folsom will appear in the May issue of WORLD OIL.

Is a Salt

By W. C. SHEAD and EDWIN R. ALLEN, Statisticians
Tide Water Associated Oil Company, Houston

THERE HAS LONG been a rather widespread belief among Gulf Coast oil people that drilling on the north flank of salt domes has considerably better chance for success than south flank drilling. Apparently this belief or superstition is not based on fact for this study goes a long way towards proving that regardless of the flank on which a well is drilled, odds are pretty much the same.

On basis of 7175 wells drilled on 73 onshore and offshore salt domes in South Louisiana, it was found that the north flank did tend to have a slight advantage, but the difference could be considered statistically insignificant.

After an exhaustive search of literature failed to disclose anything on the subject, this study was undertaken. The project required the detailed counting of all wells drilled on the productive salt domes of South Louisiana, both onshore and offshore, as reported by the Louisiana Department of Conservation. This compilation does not include the Jennings Dome, for which an up-to-date map was not available, and the Calcasieu Dome, which is not productive. The 73 salt domes studied include 63 onshore with their 6962 wells, and 10 domes with 213 wells on the Continental Shelf.

Statistically, it can be concluded that while north flank drilling has enjoyed a slight edge, with an average success rate of 64.33 percent against the south flank's 62.02 percent, the 2.31 percent difference is not significant. From these results, it is logical to assume that no real difference exists, and that the chance of drilling a producing well is affected very little, if any, by choice of salt dome flank.

Dome's North Flank Its Best Prospect?

Many believe that it is, but history lends practically no support to the north-over-south flank theory. This survey shows why.

Percentages of producing wells of the total drilled, by flanks, were:

	North Flank	South Flank
Onshore	63.92%	61.76%
Offshore	75.74%	72.73%

From this it can be seen that offshore results have been in the same relationship as those of the onshore wells, with the small advantage going to the north flank. Small number of salt domes drilled offshore does not allow acceptance of the findings without reservations. The 3.01 percent difference between flanks offshore again confirms conclusions above.

However, over-all success ratio of 74.65 percent offshore as compared to 62.94 percent onshore does invite some discussion. This difference of 11.71 percent is probably due to the relatively small number of wells drilled offshore. In the future, as offshore exploration increases, ratio of success should tend to drop toward the onshore ratio, or at least toward the higher national average.

To determine the possibility that success might have been appreciably higher on either the east or the west flanks, the study was extended to include them. In this instance, northeast and the southeast flanks were combined and compared with combined northwest and southwest quarters. The 60.96 percent success rate found for the east flank and the 65.79 percent for the west bore out the original conclusion that difference was negligible.

A comparison also was made between major producing formations encountered in 73 salt dome fields:

	North Flank	South Flank
Miocene Formation ..	63.88%	63.27%
Frio Formation	66.98%	55.77%
Wilcox Formation ..	51.55%	65.85%

Total wells drilled to the Miocene formation had success of 63.59 percent, with no difference between tests on north and south flanks. Total Frio formation wells scored 62.76 percent success, with an 11 percent advantage being in favor of the north flank. Wells drilled to the Wilcox were 59.55 percent successful, and the comparison of these wells, by flanks, showed the only noticeable deviation from the trend. North flank of the Wilcox recorded a success rate of 51.55 percent compared with 65.85 for the south flank. This difference probably is due to the small number of wells completed in this formation, as only two of the 73 fields studied produce from the Wilcox.

An interesting comparison is relationship of successful salt dome drilling to national drilling average. Statistics from the U. S. Bureau of Mines place the national average at 69.64 percent successful for the period of 1931 to 1953. This period was used because most of the drilling on salt domes fell in that era.

When the national average is compared with the success rate of 62.94 percent on onshore Louisiana salt domes, a sufficient margin is found to indicate that onshore salt dome drilling has been less successful than that of the U. S. as a whole. However, the relatively small number of salt dome wells does not lend sufficient basis for drawing a reliable comparison between the two records.

In a study of this nature it is desirable to know by what means the results were obtained before the find-

Summary of Wells Drilled on 73 South Louisiana Salt Domes by Producing Formation

Formation and Flank	Oil	Gas	Dry	Total Wells	Percent Successful
FRIO—					
Flank—					
Northwest	239	33	128	400	68.00
Northeast	349	24	190	563	66.25
Total North	588	57	218	963	66.98
Southwest	202	7	121	330	63.33
Southeast	103	12	136	251	45.82
Total South	305	19	257	581	55.77
Total Wells	893	76	575	1544	62.76
MIOCENE—					
Flank—					
Northwest	912	72	474	1458	67.49
Northeast	748	107	566	1421	60.17
Total North	1660	179	1040	2879	63.88
Southwest	698	74	430	1202	64.23
Southeast	753	77	500	1330	62.41
Total South	1451	151	930	2532	63.27
Total Wells	3111	330	1970	5411	63.59
WILCOX—					
Flank—					
Northwest	19	....	13	32	59.38
Northeast	31	....	34	65	47.69
Total North	50	....	47	97	51.55
Southwest	19	....	17	36	52.78
Southeast	61	1	25	87	71.26
Total South	80	1	42	123	65.85
Total Wells	130	1	89	220	59.55

ings are accepted. The authors were assisted by George Hingle and George Wise, geologists with Tide Water Associated Oil Company, who marked off field maps by dome flanks. Some of the maps had salt outlines contoured, so arrival at the center of the dome was a simple matter of centering on the highest contour. On uncontoured maps, the wells with the shallowest salt were taken as the approximate centers of the domes. The domes were then quartered and the wells counted and classed as to results. Those wells that were completed as producers, but since depleted and abandoned, were tabulated as originally completed. Wells drilled for sulful were not included.

This study was conducted strictly from a statistical viewpoint. No geological evaluation was made, and no flank production histories were determined.

Results of Drilling by Flanks on 73 South Louisiana Salt Domes

Name and Producing Formation*	NORTH FLANKS						SOUTH FLANKS						Total Wells
	Northwest Flank			Northeast Flank			Southeast Flank			Southwest Flank			
	Oil	Gas	Dry	Oil	Gas	Dry	Oil	Gas	Dry	Oil	Gas	Dry	
ONSHORE—													
Anse La Butte (M)	14	....	15	11	3	36	79	....	42	18	2	35	255
Avery Island (M)	35	1	7	....	....	2	....	....	2	33	....	6	86
Barataria (M)	27	1	5	10	1	3	5	1	8	26	3	6	96
Bayou Bleu (F)	31	1	8	14	1	19	13	....	22	34	....	15	158
Bayou de Chene (M)	21	1	4	3	1	2	6	2	4	7	1	5	57
Bay Junop (M)	....	1	7	3	3	16	....	....	5	....	....	4	39
Bayou Bouillion (F)	6	1	4	4	....	4	1	....	5	....	....	6	31
Bayou Choctaw (F)	24	....	9	16	1	14	24	....	11	7	....	8	114
Bayou Couba (M)	6	....	11	6	....	5	15	....	10	15	....	10	78
Bayou Des Allemands (M)	10	6	2	14	1	7	14	2	7	8	....	4	75
Bayou Des Glaises (F)	7	....	4	7	....	9	1	1	8	....	....	1	38
Bayou St. Elaine (M)	54	3	13	16	2	26	1	6	31	12	2	13	179
Belle Isle (M)	7	1	8	2	....	13	6	2	6	5	1	11	62
Black Bayou (M)	18	....	14	12	....	17	20	....	10	17	....	15	123
Bully Camp (M)	18	2	8	13	2	8	2	....	13	3	....	13	82
Caillou Island (M)	57	1	7	33	3	6	79	2	13	36	7	10	254
Cameron Meadows (M)	....	....	7	42	5	9	10	7	8	1	....	2	91
Chacahoula (M)	....	....	27	17	7	53	17	5	9	19	3	15	172
Chenneyville (W)	9	....	4	7	....	2	17	....	6	9	....	2	56
Convent-Hester (M)	1	....	6	2	6	8	5	2	4	4	7	7	52
Cote Blanche Island (M)	....	....	22	....	....	11	4	....	4	3	1	7	52
Cut-Off (M)	....	....	....	....	....	....	....	....	....	2	1	2	5
Darrow (M)	8	....	11	22	1	18	7	2	10	5	....	8	92
Dog Lake (M)	2	1	15	21	3	7	19	....	17	19	1	5	110
East Hackberry (M)	26	4	15	28	4	17	72	1	40	22	....	18	247
Edgerly (F)	6	....	10	12	....	6	5	1	6	77	....	20	143
Fausse Point (M)	23	2	24	8	1	9	....	....	4	5	1	18	95
Four Isle Bay (M)	4	....	12	3	4	17	5	3	4	....	2	4	58
Garden Inland Bay (M)	1	2	7	29	1	10	40	....	....	14	2	8	114
Gueydan (M)	11	1	4	11	2	7	9	1	10	13	3	5	77
Henderson (F)	7	1	6	5	1	3	5	....	3	2	....	4	37
Iberia (M)	38	1	18	13	3	27	29	2	20	44	2	9	206
Iowa (F)	66	16	10	21	8	7	1	3	8	8	1	6	155
Jeanerette (M)	37	5	14	16	7	13	2	....	7	10	....	4	115
Jefferson Island (M)	....	....	5	5	....	11	15	....	6	3	2	6	53
Lake Barre (M)	14	....	9	20	2	7	17	4	4	10	....	6	93
Lake Hermitage (M)	5	6	4	....	....	3	....	1	10	2	3	9	43
Lake Mongoulois (F)	6	....	1	12	4	5	5	....	5	....	....	2	40
Lake Pelto (M)	17	2	14	22	2	7	18	....	2	21	4	8	117
Lake Washington (M)	42	....	25	17	2	13	8	1	10	30	3	24	175
Leeville (M)	61	3	12	58	6	14	33	1	11	51	3	7	260
Lockport (F)	4	....	6	13	0	7	21	2	7	15	....	9	84
Napoleonville (M)	11	....	15	8	4	13	11	4	27	....	2	17	112
Pine Prairie (W)	10	....	9	24	....	32	44	1	19	10	....	15	164
Port Barre (F)	21	1	20	18	3	20	2	1	4	36	4	5	135
Potash (M)	9	2	22	2	2	11	16	2	4	11	....	4	85
Raceland (M)	10	3	4	3	5	3	5	3	6	7	1	9	59
Section 28 (F)	17	4	8	19	1	7	1	....	1	12	....	11	81
Sorrento (F)	3	3	9	12	1	19	....	1	9	2	2	10	71
Starks (F)	17	3	22	18	2	29	4	....	28	5	....	18	146
Sulphur Mines (M)	5	....	12	17	1	3	21	....	6	45	....	5	115
Sweet Lake (M)	....	....	1	....	....	3	....	....	4	21	6	6	41
Timbalier Bay (M)	50	1	5	10	....	5	....	....	....	7	....	9	87
Valentine (M)	25	12	15	11	8	18	32	9	6	2	1	14	153
Venice (M)	28	....	3	51	....	7	23	1	16	14	....	6	149
Vermilion Bay (M)	1	....	4	....	2	5	3	1	10	....	1	2	29
Vinton (F)	21	1	3	76	2	9	18	1	5	4	....	2	142
Weeks Island (M)	52	3	6	40	2	6	16	....	10	25	....	10	170
Welsh (F)	3	2	8	102	....	32	2	2	14	....	....	4	169
West Bay (M)	17	....	4	34	2	....	12	3	5	12	1	2	92
W. Cote Blanche Bay (M)	21	1	1	12	2	....	12	1	1	14	3	2	70
West Hackberry (M)	29	3	14	77	1	65	36	1	58	40	3	22	349
White Castle (M)	16	1	2	12	....	6	13	1	7	9	1	6	74
Total Onshore	1089	103	601	1114	125	771	901	84	652	886	80	556	6962
Percent Successful		66.48			61.64			60.17			63.47		
Percent Successful			63.92						61.76				62.94
OFFSHORE—													
West Delta—Block 30 (M)	2	....	....	1	1	1	....	1	....	....	....	1	7
Grand Isle—Block 16 (M)	2	2	6	....	1	4	....	....	....	....	....	1	16
Grand Isle—Block 18 (M)	4	....	....	4	....	1	6	1	1	3	....	1	21
Bay Marchand—Block 2 (M)	27	....	4	2	....	3	4	....	3	21	1	....	65
Timbalier Bay (M)	36	....	2	6	....	5	....	....	....	6	....	5	60
South Pelto—Block 20 (M)	....	....	1	....	....	....	....	1	....	....	....	....	2
Ship Shoal—Block 32 (M)	1	....	....	1	....	....	....	....	....	....	....	1	3
Ship Shoal—Block 72 (M)	....	....	....	....	2	1	3	....	1	....	....	....	7
Eugene Island—Block 110 (M)	....	....	1	....	2	3	....	2	1	....	....	2	11
Eugene Island—Block 126 (M)	9	....	....	....	....	1	3	1	3	3	....	1	21
Total Offshore	81	2	14	14	6	19	16	6	9	33	1	12	213
Percent Successful		87.57			51.28			70.97			73.91		
Percent Successful			75.74						72.73				74.65

* Major Producing Formation: (F) Frio; (M) Miocene; (W) Wilcox.

Why Louisiana's Offshore Prospects Look Better

Increased attention is being directed toward offshore activity in the Gulf of Mexico. While the Texas coastline is getting its share of the play, geologists believe hottest prospects are off Louisiana where the river-deposited Miocene sands extend far out into the Gulf.

The Mississippi is dictating the difference between excellent and mediocre offshore prospects.
LA.
Gulf of Mexico
Thick Miocene sands deposited far out in the Gulf provide generally shallower depths.

THE MISSISSIPPI RIVER'S behavior since the beginning of Miocene time, perhaps 20 million years ago, seems to dictate the difference between excellent and mediocre offshore prospects. Offshore fields in the Gulf of Mexico are just beginning to bear real dividends for operators engaged in the tremendous task of offshore exploration and development.

The river deposited thick Miocene sands far out into the Gulf as its channel migrated back and forth across and west of its present-day delta. The greater areal extent of these sands is off Louisiana. And the Mississippi, having already afforded operators a big drilling platform that its delta represents, continues to deposit sediments far out to sea to accommodate drillers with generally shallower marine depths off Louisiana than off Texas.

Geologists believe that fully 30,000 feet of Miocene section occurs under the coast of southwestern Louisiana in what is called the Barton geosyncline. Many prolific oil and gas fields have been discovered in thick Mio-

cene sands along the Louisiana coast, and particularly on the Mississippi delta. Generally speaking, there have been two generations of drilling along the Louisiana coast.

The first was largely restricted to salt domes. Afterwards, inter-domal structural traps became profitable to drill, and this aspect, along with more favorable allowables, has helped bring on a second spurt to currently-booming southern Louisiana.

Geologists who have projected sand deposition known on the coast toward the offshore believe that in Miocene times the Mississippi river migrated westward to deposit sands off the Texas coast as far as Galveston County as an approximate limit. A very interesting test is now being drilled by Continental Oil Company and Shell Oil Company 63 miles southeast of Galveston on a 100,000-acre block held jointly by the two companies located just west of the Louisiana-Texas boundary extended southward from the Sabine river mouth. C. G. Glasscock's mobile platform "Mr. Gus" is being used for this test in 90 feet of water. It will be interesting to learn not only whether this well produces, but also how well the Miocene sands may be developed, and how the test affects the general sand development picture from landward to seaward.

It is doubtful that the Mississippi river mouth has ever been located much farther east than it is today. This is shown by the fact that the present mouth is only 10 to 12 miles from the edge of the Continental Shelf, defined as the 70-fathom mark, at which depth the Gulf's floor begins to drop abruptly after showing a very gradual slope seaward to the 400-foot depth mark. South of Mobile Bay, the edge of the Shelf is 40 miles seaward, as compared to the Shelf's maximum width of 150 miles south of the Sabine river mouth.

Many geologists believe, therefore, that the prolific offshore Miocene prospects are restricted roughly by the meridian running southward from the Mississippi river mouth on the east to that running southward from the proximity of Galveston, and the prospective area being of course restricted on the south by the maximum depth of water in which drilling is feasible. Obviously this represents a huge area.

Thus the main geological problem in offshore exploration is to locate good structures in areas where sand conditions are also favorable. Seismograph work, aided greatly by rapid advances in instrumentation, electronic surveying, and also by quick transition of seismic personnel to the ways of maritime living, has proceeded rapidly.

Seismic work is the only aspect of offshore exploration that is cheaper than the same operation on land. Furthermore, it has not been particularly delayed by the long legal fight that took place in regard to jurisdiction over the submerged lands. Estimates indicate that four-fifths of the offshore area within the 20-fathom line between Nueces County, Texas, and the Mississippi river mouth has had reconnaisance seismic coverage. Total cost of this work to date is estimated at almost $130 million.

Offshore Gulf of Mexico production dates from March, 1938, with the discovery of the Creole field off Cameron Parish, Louisiana, where an oil well drilled from a wooden platform was completed from about 5100 feet. In August, 1945, the State of Louisiana held the first offshore sale, and Magnolia Petroleum Company, the only bidder, gained 129,000 acres at $5.10 per acre bonus. At the lease sale of July 1955 by the Department of the Interior, some bids topped $2100 per acre, and the average sale price was about $400 per acre.

Development offshore was held back during President Truman's administration by the legal tangle over ownership of the submerged lands. In June, 1950, when over a million acres were under lease to various companies offshore from Texas and Louisiana, the U. S. Supreme Court ruled that all Gulf waters represent federal property. All offshore drilling stopped as a result. Two Congressional acts passed during the middle of 1953, the Submerged Land Act, and the Outer Continental Shelf Act, helped clarify the ownership situation.

The boundary between state and federal jurisdiction over submerged lands was recognized as the "historical (state) boundaries" and was defined as being three miles seaward from mean low tide in all cases except that of the West coast of Florida, and the State of Texas, where 10½ miles seaward from mean low tide was defined as the boundary. Louisiana is claiming 10½ miles also, as representing its "historical boundary," and the federal government is currently pressing a law suit intended to clarify the disputed strip between three and 10½ miles seaward from mean low tide in its favor. Louisiana's jurisdiction over the surface of the islands within the 10½ mile seaward line has been recognized.

The two acts of Congress of 1953 also allowed the Interior Department to ratify the state-issued oil and gas leases that were in effect and in good standing at the time of the passage of the pertinent Federal legislation. At the end of 1955, 2.75 million acres were under lease offshore in the Gulf of Mexico.

The Bureau of Land Management has been fairly prompt in clarifying and defining ways and means of offshore operation. Bid sales in October and November, 1954, brought $142.4 million into the U. S. Treasury in exchange for 486,869 offshore Gulf acres leased for oil, gas, and sulfur exploration. This one sale comprised over half of the BLM's income in 1954, which was 16 times its federal budget for the same year.

On December 7, 1955, the Bureau of Land Management added 1,365,000 acres to leasable Outer Continental Shelf lands. Two new sections had been mapped by federal cadastral engineers. The areas consisted of two wedge-shaped tracts, previously comprising a void extending from Chandeleur Sound near New Orleans to Old Mexico. On December 10, 1955, BLM Director Edward Woozley issued an invitation for bids on Outer Continental Shelf tracts. The BLM seems to be out for bids as fast as it can accurately define the areas and issue maps thereon.

In addition, Circular 1946, codifying regulations governing rights-of-way for oil and gas pipe lines in the submerged lands was recently released by the BLM. The coastal states have jurisdiction of oil and gas pipe line rights-of-way from the Outer Continental Shelf shoreward.

Increasing federal revenues from offshore oil may work in favor of the oil companies in time, politically

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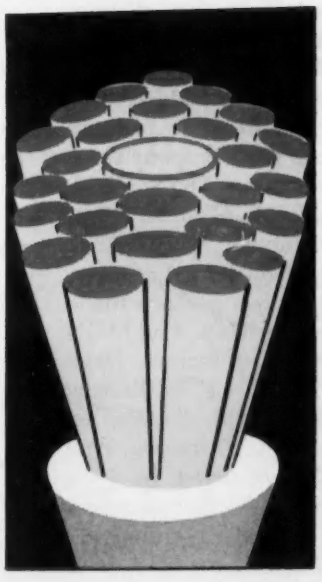

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speaking. The U. S. government gets one-sixth royalty on production, $3 per acre annual rentals on non-productive leases, in addition to the big lease bonuses. The political forces, currently so intent on hamstringing the oil industry through price control of natural gas at the wellhead, lowering of depletion allowance, and perhaps some anti-trust actions that have been rumored, may be somewhat deterred from such action in view of increases in Federal income as a result of the more vigorous offshore activity affecting its submerged lands.

To date, almost 800 wells have been drilled offshore in the Gulf of Mexico, with a success ratio of almost 70 percent. This has occurred despite the high proportion of rank wildcats drilled, and the fact that so far the play has been almost totally confined to apparent salt dome structures. Most companies participating in the offshore work concentrate on validating their short-term leases (none have longer than five-year primary terms). Evaluation of their findings to date is difficult because too few wells have been drilled in most fields, and most of the companies decline to release full data. About 20 major offshore fields have been found, two-thirds of them being oil fields. The industry is estimated to have expended over $1 billion to date in Gulf offshore work. Continental Oil Company alone has spent more than $65 million. Though the California Company leads in offshore production with 37,322 barrels daily from offshore Louisiana alone, Continental has perhaps made the most spectacular news. The MCN group (Magnolia, Continental, Newmont Mining) Well 4-F in Eugene Island Block 126 Field, located on the west flank of a piercement-type salt dome, was completed in 1954 after logging over 600 feet of effective oil sand, distributed among 17 separate pays. More than 200 feet of net effective pay was found above 6100 feet of depth.

Consequently, reserve estimates for the area jumped abruptly. In October, 1955, the CATCo group (Continental, Atlantic, Cities Service, and Tidewater, 25 percent each, Continental operator) drilled a test 20 miles off Grand Isle, Jefferson Parish, Louisiana, 50 miles west of the Mississippi river mouth. It was a record offshore well for both drilling depth (15,058 feet) and depth of water (97 feet). The stationary platform alone, from which as many as nine wells may be drilled, cost $1.5 million. This tremendous gamble, located on a 60,000 acre block, was successfully completed, flowing at a rate of 410 barrels daily of 37 gravity oil from the perforated interval 13,614-20. Another interval from 9868-74 tested 348 barrels per day. Both gages were on $^{10}/_{64}$-inch chokes.

How great the eventual offshore reserves in the Gulf will prove to be is a highly nebulous consideration. One estimate of 13 billion barrels was once proposed by the U. S. Geological Survey. There are many structures in the Gulf of Mexico, some so obvious as to be indicated by contours of the depth of the sea floor. As early as December, 1949, 87 structures had already been found off Louisiana, and 33 off Texas. There are at least 164 known topographic features present on the Continental Shelf of the Gulf of Mexico, many of which may be salt domes, perhaps bearing oil, gas, and/or sulfur. If onshore Louisiana experience proves true offshore, prolific inter-domal structures, bearing oil, may be found, after the salt domes have all been drilled. Geologically, the Continental Shelf is a basically unstable realm. Faulted structures should be there. Wherever good permeable sands occur too, prospects are good.

But operating expenses are tremendous. Marine pipelining, and marine corrosion, will be increasingly serious and expensive factors.

Offshore from South Texas, the prospects are much leaner. Whereas off the Sabine river mouth, the 120-foot depth marker is 80 miles offshore, the same depth occurs less than ten miles offshore from the mouth of the Rio Grande. There is a Miocene basin of sorts in southeastern Cameron County, Texas, perhaps attributable to the ancestral Rio Grande, but extensive drilling by The Pure Oil Company and an independent during the early 1940's resulted only in the discovery of a little high-pressure, low volume gas near Port Isabel.

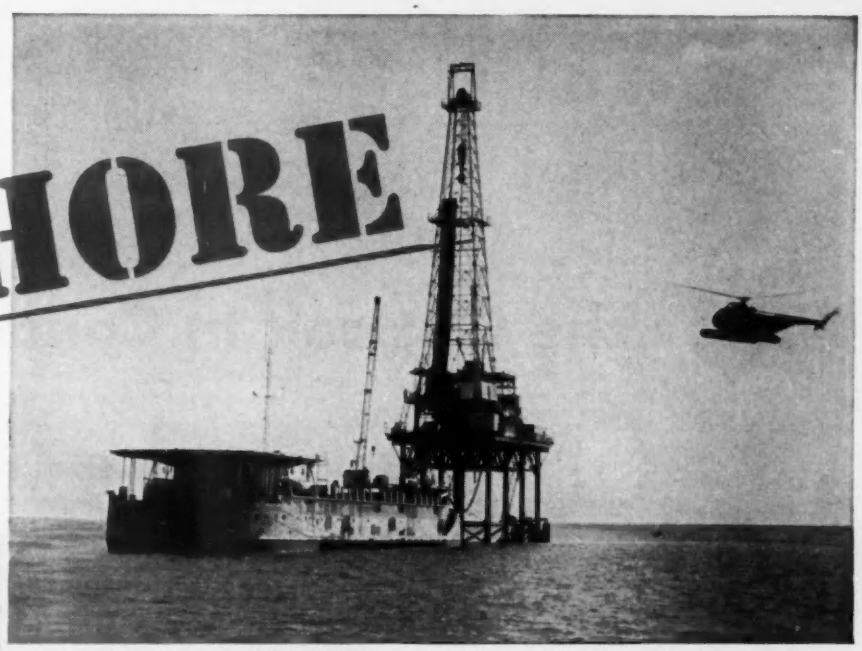
Throughout the length of the South Texas coast, it appears that near-future offshore drilling will be restricted by water depth to nearshore areas. Geologically it will be determined by specific formation trends, paralleling the coast, some of which trends are yet to be specifically defined. Though the Rio Grande, Nueces, and Colorado rivers may have some bearing on Miocene sand deposition, they had nothing like the volume of water and sediments nor the influence on oil accumulation, nor on depth of near-delta sea water that the Mississippi river has in the offshore Gulf of Mexico.

The southernmost find to date off the middle and south Texas coasts is Standard of Texas' Chevron field, off Kleberg County south of Corpus Christi, about 20 miles southwest of Mustang Island field. The two fields are generally similar. Chevron is more recent, having been discovered in December, 1954, when Stanotex's first well in State Tract 948 was completed for 373 barrels of 40-gravity oil through a $^{12}/_{64}$-inch choke from a thin Marginulina sand stringer at 7760-7766. By November, 1955, Stanotex had 3 oil wells and six gas wells in the field. Several Marginulina sand stringers were proven productive, and some interesting Frio and Miocene sands were logged, but neither the sands nor the reserves indicated here show any such promise as those of the Miocene off the coast of Louisiana and easternmost Texas.

Off Florida's West coast, Standard of California and Caribbean Oils Incorporated are reported to be involved in seismic operations on a 400-mile strip from Appalachicola Bay southward to Naples. This appears to be a deep Cretaceous lime play. Tertiary limes and marls, generally considered non-prospective, and underlying Cretaceous limestones make up most of peninsular Florida. Western Florida's only field, Sunnyland, near Fort Myers, produces from the Glen Rose equivalent of lower Cretaceous below 10,000 feet.

California's submerged lands have produced about 270 million barrels of oil to date, many times that produced from the Gulf of Mexico so far. But the Gulf has more room and more prospects. And it's now beginning to pay. —The End

OFFSHORE



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A World Oil Interview —with

Theo. A. Link
President Elect, A.A.P.G.
Consultant, Calgary

What's the Outlook in Canada?

Productive potential of the granite wash is providing a stimulating challenge for oil prospectors. For the answers to some questions about Canadian exploration and development, WORLD OIL went to the president-elect of AAPG. Here are his replies.

By GILBERT M. WILSON
WORLD OIL Staff

Q *From the standpoint of a geologist and consultant who, for many years has participated actively in the Canadian oil industry, would you say, Dr. Link, that the future of the Canadian oil industry holds as much promise, expansionwise, as has been demonstrated during the past nine years since the Leduc discovery?*

A Yes, qualified only to the extent that there be no drastic change or changes in the economic trend within Canada and the U. S., the oil industry in Western Canada will expand to several or many times its present size. Oil reserves will continue to be added, as during the last nine years, under the assumption that the present exploratory effort is also maintained.

Q *Looking far down the road, as you must in your profession, would you care to express your views on where future important oil reserves may be found in Western Canada provinces? Also, would you care to comment on any specific areas, or regions, where new types of accumulations, or new horizons, might bear closer scrutiny than they have received in the past?*

A If I could pinpoint such prospective areas and/or geological horizons, I would not divulge that in an interview for obvious reasons. However, the recent confirmation at Red Earth, in northern Alberta, of the great possibilities in the "granite wash" is an example of what can happen if a failure or two in finding commercial production within a given horizon does not too greatly divert or discourage those in charge. Shows of oil within the equivalent of the "granite wash"

THEO. A. LINK, consultant and newly elected president of the American Association of Petroleum Geologists, graduated from the University of Chicago in 1918. He became assistant field geologist with the Canadian Geological Survey and the following year joined the Empire Oil and Fuel Company as a field geologist. In 1919, Link became affiliated with the Imperial Oil Ltd. to handle assignments in Nova Scotia, Northwest territories, Alberta and British Columbia. From 1922 until 1926 he was field geologist and supervisor in Columbia, S. A. for International Petroleum Co., Ltd. In 1927 he returned to the University of Chicago where he was awarded a doctorate in geology.

THEO. A. LINK

He then returned to Western Canada as geological supervisor for Imperial Oil Ltd. Except for a short leave to supervise the Petroleum Industries Exhibit at the 1933 Century of Progress, Chicago, and to act as chief geologist on the Canol Project, N.W.T., Canada for the U. S. Engineers and Imperial Oil Ltd., Link remained with the latter company, reaching the position of chief geologist, until 1948. At that time he formed his own consulting organization. Link is past president and now patron of the AIMME, Canadian Institute of Mining Engineers, American Association for the Advancement of Science, Geophysical Union, Sigma Xi and was the Barlow Medal recipient in 1949.

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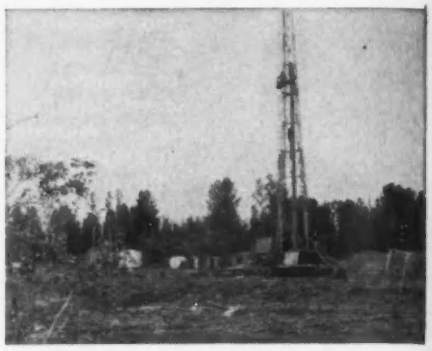
were obtained and were on record before the Leduc discovery in 1947.

Northeast British Columbia and adjacent Northwest Territories are excellent hunting ground and when a greater number of interests begin working in Saskatchewan more discoveries will be made there. Some of the larger companies were acreage poor and "bit off more than they could chew" in Saskatchewan. Now they need help.

Stratigraphically, a great deal more testing can be done throughout the entire sedimentary column in Western Canada. This will reveal new producing horizons; and previously tested ones will also prove productive.

Q *What are the present crude reserves of Western Canada, and can you comment on the rate at which new reserves are being found—whether still on the increase, or starting to level off?*



Drilling well in Pembina field which, since its discovery in mid-1953, already accounts for some 38 percent of Western Canada's estimated 4 billion barrels of crude oil reserves. The field is a stratigraphic trap; ultimately may have a productive area in excess of 600,000 acres.

A The present proven recoverable oil reserves in Western Canada are estimated to be 4 billion barrels. In addition, the Canadian Petroleum Association recently estimated that proven recoverable condensate reserves in the order of 208,000,000 barrels are present in the gas fields of Alberta and northeast British Columbia. The oil reserves in Western Canada have been increasing at an average rate of 10 percent during the past years and have shown no indication of leveling off.

Q *Although Pembina's limits still are not yet defined, would you care to comment on the probable ultimate extent of this huge field; whether it might be linked ultimately with other Cardium producing fields to the southeast? Percentagewise, about what does Pembina's Cardium crude reserves amount to in the Alberta (or Western Canada) total?*

A It is probable that the ultimate extent of Pembina will be in excess of 600,000 acres. It is rather doubtful, but not beyond the realm of possibilities, that the field will be linked with the Cardium sand fields to the southeast. Pembina's proved recoverable reserves currently comprise 38 percent of Western Canada's total.

Q *Outside of Pembina, what areas in the four western provinces appear to hold the greatest promise for sustained exploration and development effort during the coming year or so?*

A Southeast and southwest Saskatchewan probably hold the greatest promise for continued exploration and development in the coming year, but

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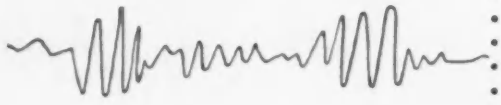

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Inadequate testing of sands in Western Canada prior to the 1947 Leduc discovery postponed the finding of commercial production in the Viking sand in the Armena and adjacent areas of central Alberta as well as in Saskatchewan. Shown above is a typical drilling well operating in the then-developed Armena field in 1952.

northeast British Columbia will soon become a favored area.

Q *It has been said that discovery of the productive Cardium sand at Pembina was more or less "accidental" in routine up-the-hole testing of an about-to-be-abandoned wildcat. Do you feel, Dr. Link, that possibly other "overlooked" areas or horizons ultimately might be discovered (or rediscovered) in already worked-over areas?*

A The inadequate testing of sands in Western Canada before the 1947 Leduc discovery postponed the finding of commercial production in the Viking sand in the Armena and adjacent areas; also in Saskatchewan and other localities. During those days it appears that the drilling departments merely wanted to "make hole" as fast as possible on the wildcats just as on the development holes. Reexamination and redrilling, with proper testing of old and fill-in areas, will be a very large factor in maintaining the upward trend of new reserve discoveries.

Q *In the future, and particularly since Pembina, do you believe the shoreline or pinch-out type of reservoir will be sought-after more energetically?*

A Geologists' thinking, like women's styles, change even within a given season. At the present time the "granite wash" play is the vogue, but things will change from shore-lines to reefs, from foothills to plains, from structural traps to stratigraphic, etc., etc. One must remember the story of the prospector in Heaven who started the rumor about a strike in Hell.

Q *To what principal exploration or geophysical tools do you attribute the*

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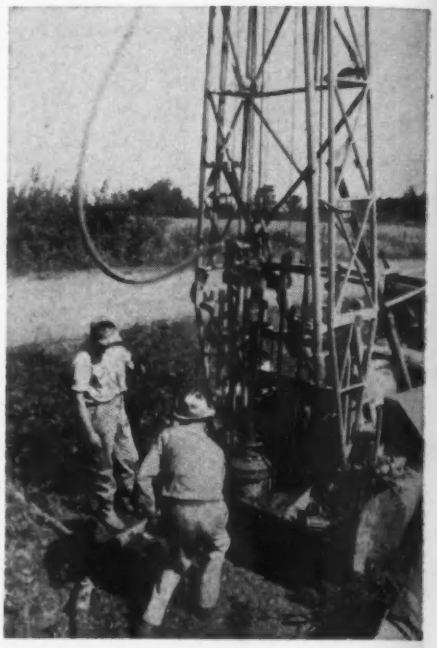
bulk of Canadian discoveries, naming several of the more noteworthy fields and the manner of discovery?

A The first Devonian reef discoveries like Leduc, Redwater, Bonnie Glen, Wizard Lake, etc., were the result of seismic reflection surveys, but some of these required several surveys, and changes in technique as well as interpretation, before success was attained.

Regional and "trend" geology was coupled with these and subsequent reef, discoveries. Pembina, like Red Earth, should have been based primarily on regional stratigraphic geology obtained from deep tests.

The Cardium sandstone, for example, was known to exist in the Foothills Belt with a thickness as much as 300 feet, while in the Leduc area it was found missing. The Armena area was also a stratigraphic play which paid off.



Reflection and refraction seismic methods in the immediate foreseeable future probably will continue to hold their own in reef exploration work. Granite wash and similar sands resting on pre-Cambrian highs doubtless will have better chance of discovery by means of gravity meter and magnetometer surveys. Shown is typical geophysical drilling rig operating in Redwater area of Alberta.

Q *Which of the presently-known geophysical methods or techniques appear to hold most promise, in the foreseeable future, in the muskeg-covered regions of northern Alberta, British Columbia, and N.W.T.?*

A In the immediate foreseeable future the seismic reflection and refraction method will continue to hold its own in "fill in" reef areas where, from a geological standpoint, reef trends might exist. Granite wash and similar sands resting on the Pre-Cambrian and/or surrounding old islands and promontories, might be detected by means of gravity-meter and/or magnetometer surveys.

Q *Would you care to comment, Dr. Link, on some of the later techniques that have received publicity in recent years, such as magnetic tape recording of shot data; residual mapping technique; the Reynolds method; airborne scintillation counters to detect so-called "halo" effect, etc.; and their application to any particular region of Western Canada?*

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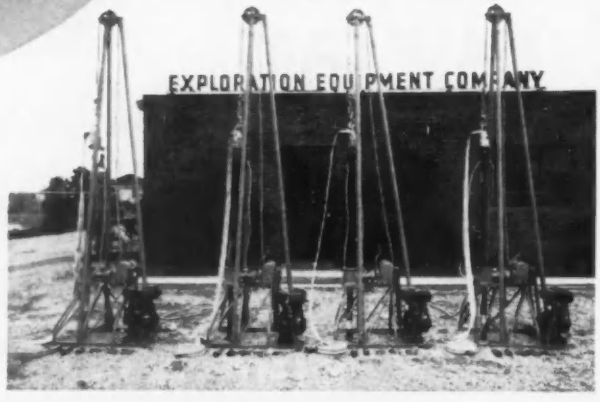

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Exploration outlook is good as long as good markets are available

A All new techniques are, and should, receive attention and adequate trials. Which of these will prove satisfactory cannot be predicted, but the magnetic tape and Reynolds method are becoming increasingly popular at the present time.

Q *Canadian gas, its development and possible market outlets, has been in the news very much recently. Do you believe that completion of the two principal pipe lines (Westcoast and Trans Canada) now under way or nearly so, will stimulate an appreciable increase in gas exploration and development work?*

A Once a definite market for gas has been established and is actually being served, such a market usually grows larger, and additional ones are then added, so that more reserves must be found. In other words, as markets increase from day to day, reserves must also be replenished from day to day—or year to year, as the case may be.

Q *What are the estimated recoverable gas reserves of Western Canada? Would you say additions to reserves are increasing significantly and possibly will maintain or exceed this rate in the foreseeable future—particularly with pipe line outlets being almost a certainty?*

A The estimated proven recoverable gas reserves for Western Canada now stand at roughly 20 trillion cubic feet. These reserves will increase incidental to the search for oil, as well as by increasing the area of reserves around single well pools. If necessary, the search for gas on its own would increase the reserves even faster.

Q *While with Imperial, you were active in exploration work leading to the discovery of Norman Wells field. Do you feel that that field ultimately may be found to be one in a chain of Devonian Reef fields extending between there and Central Alberta Plains Area?*

A An Upper Devonian reef trend may eventually reveal a relationship between the Northern Alberta and the Lower Mackenzie river reefs, like the Norman Wells reef pool and the exposed Hosier Ridge and Kee Scarp reefs. However, such a trend could have had a north-easterly swinging loop now eroded from the pre-Cambrian shield, while the possible connection could eventually be traced within the Rocky and Mackenzie mountains to the west. Of course, we would all prefer the trend to be in the subsurface of the Plains Area.

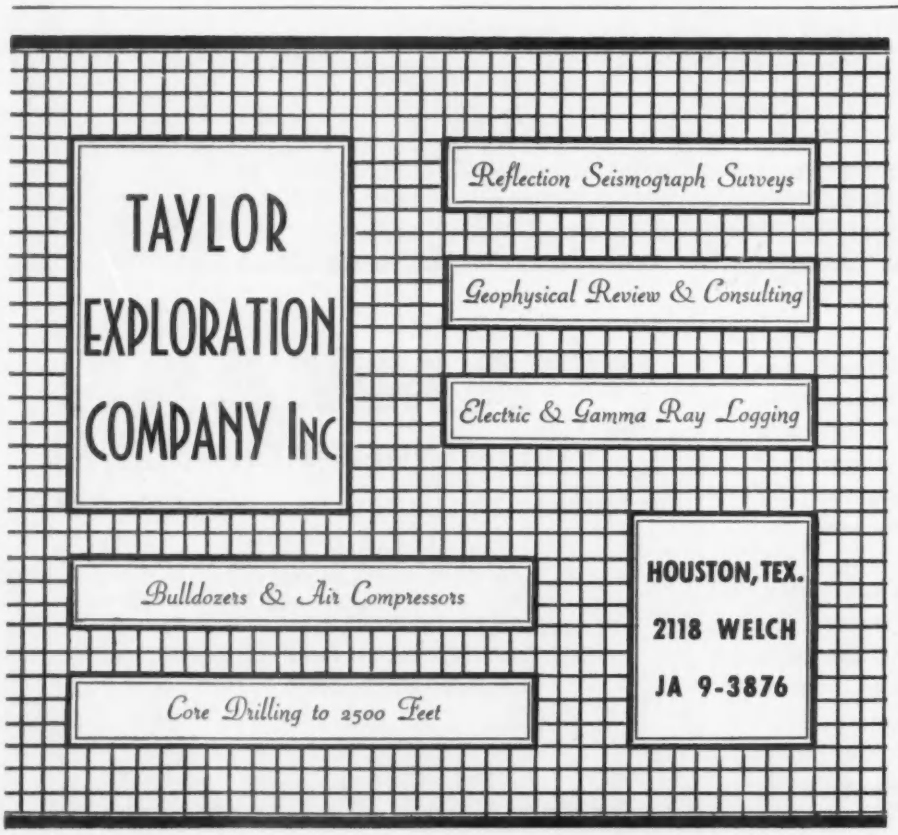
Q *Assuming a continuing favorable economic and political climate conducive to the continued spending of large sums for oil exploration, what do you feel are the several most important problems, or needs, facing the exploration phase of the Canadian oil industry?*

A Because of the fact that the Western Canadian Sedimentary Basin is still, for the greater part, a wildcat area, as compared to corresponding parts of the U.S., discoveries will continue to be found with the presently available exploration tools and methods. However, we know that improvements in tools, methods and techniques are bound to become available and interchange of these within the industry will also continue. Therefore, I see no reason for concern along these lines, and the important problems in the forthcoming phase of Western Canada's oil and gas search are not unsurmountable or unique, as long as markets are available at correct prices.

Q *In conclusion, do you have any comments to make regarding the relationship and continued cooperation between Canadian and U.S. geologists and other exploration personnel?*

A The relationship between Canadians and Americans and particularly the technical personnel, is as good as it is between a Texan and a Californian, or just as good as between a man from Quebec and one from Saskatchewan. What I mean to say is that there is always a rivalry between people from different geographical and/or political provinces or states, and in most cases it's a good thing, if not carried to extremes. The American oil men who migrated northwardly after Leduc have learned a great deal from the hardy Western Canadians in how to live as well as technical matters.

Also, scores of Canadians have gone on their own, or were sent, south across the Border to obtain the latest technical data and learn how to use it. The reverse is also the case. This exchange began long before the Leduc discovery, and will continue as long as there is an oil industry on both sides of the 49th parallel.—**The End**



Knebel Winds Up Busy Year as AAPG President

G. M. (Mose) Knebel finishes his term this month as national president of the American Association of Petroleum Geologists, during which he traveled 57,991 miles and has made speeches heard by more than 9000 people in 36 cities. The energetic Texan returned to New York on March 2 after his fifth and busiest speaking tour. On the last trip, he once made six speeches in three days.

Knebel's successor as president, Theodore A. (Ted) Link is no less colorful. Link's ability to tell an excellent joke while deeply engrossed in a discussion of the fracture pattern of a reef limestone is well known.

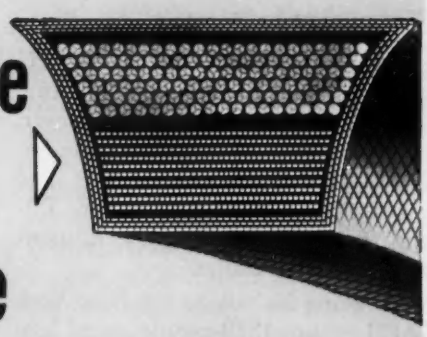
Knebel is manager of the exploration division of Standard Oil Company (New Jersey) and president of Esso Standard (Turkey) Inc. He received his B.A. in geology from the University of Texas in 1922, and worked as a geologist for about a year for each of three independent operators before joining Humble Oil & Refining Company.

He became an authority on East Texas geology, and Humble's extensive production in the East Texas field is largely a result of his foresight. Knebel became chief geologist for Standard Oil Company of Venezuela (now Creole Petroleum Company) in 1930 and later became manager of that company. In 1939 he was named an executive in the Production department of Standard Oil Company (New Jersey) and has been manager of its Exploration department since 1944.

He was chief instigator of a play in 1946 which in 1947 resulted in the discovery of Leduc field in Alberta. Knebel is a member of the API and of several exploration and other oil trade societies, in addition to the AAPG. His recent statistical study entitled "The Habitat of Oil" has won wide acclaim throughout the industry. He has given this talk in many places throughout the country.

Some of his travels during the period from April 1, 1955 to March 2, 1956 have been on company business, including stops in Venezuela,

Why this curve lengthens V-belt life



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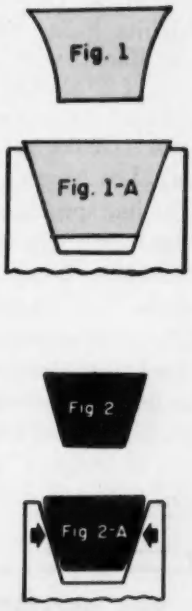

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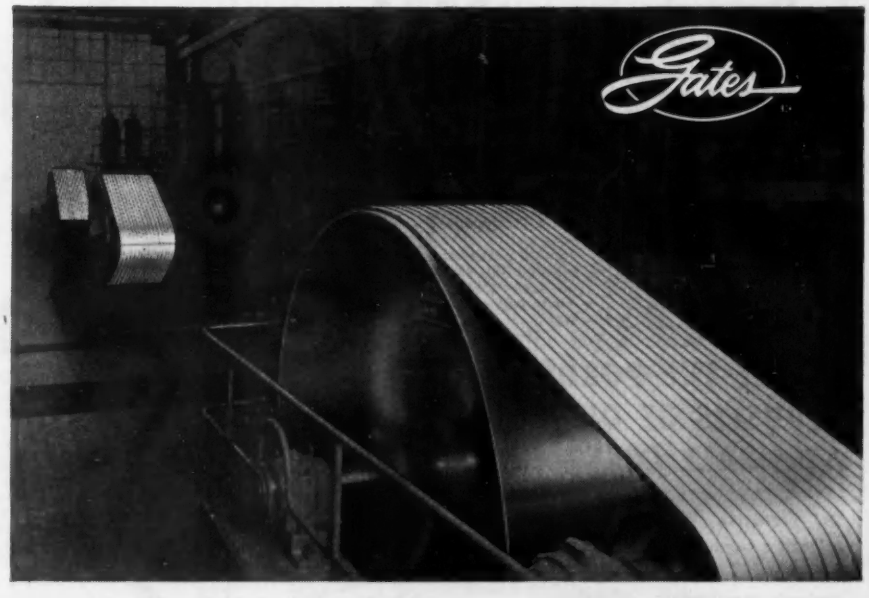

Gates Vulco Rope Drives

Peru, France and Italy, so it doesn't follow necessarily that an AAPG president must be a globe-trotter. Over half the year's total, however, have been on AAPG business. He has already made five speaking tours. The first included stops at Denver, Billings, East Glacier, Calgary, Edmonton, Jasper and Dallas.

Including his talk to the New York AAPG group, 1388 people heard him talk on this initial swing. Trip No. 2 took in Tulsa, Denver (Society of Exploration Geophysicists), Lubbock, Wichita Falls, Midland, San Angelo and Biloxi, with a cumulative audience of 2070. The third speaking tour included Oklahoma City, New Orleans (Geological Society of America), Los Angeles, Salt Lake City and Wichita, speaking before some 2230. The fourth trip took in Bloomington, Evansville, Urbana, and Mt. Vernon, where 305 tri-staters heard Knebel talk. In Washington, D. C., 310 more heard his speech at the Geological Society of America meeting. Mose's last and fastest trip took him to Jackson, Shreveport, Tyler, Austin, Houston, San Antonio, Corpus Christi, New York (A.I.M.E. meeting) Ardmore, Abilene, Roswell, Albuquerque and Denver.

G. M. (MOSE) KNEBEL
Six speeches in three days

Trip schedules have been crowded almost beyond belief. Emergency measures often had to be resorted to in order to keep them. The speaker arrived in San Antonio ten minutes before he was scheduled to speak.

The weather has been the main offender. Knebel's Evansville, Ind., talk was scheduled at a club located on a hilltop eight miles out of town. A snowstorm was in progress, and everyone had trouble driving uphill to the place. Skis might have represented a better form of locomotion. A severe dust storm, one of nature's western sandblasts, made the plane ride to Albuquerque in February less than serene.

Thus Knebel made it possible for 9394 people to share personally his broad experience, his clear analytical thinking, as well as his good nature and good humor. Certainly he's entitled now to devote more time to his fine rose garden at home in Scarsdale, N. Y. But then, he might decide to go hunting for caribou in Newfoundland or chamois in Switzerland, as he has done before. He says this helps him keep in condition.

—The End

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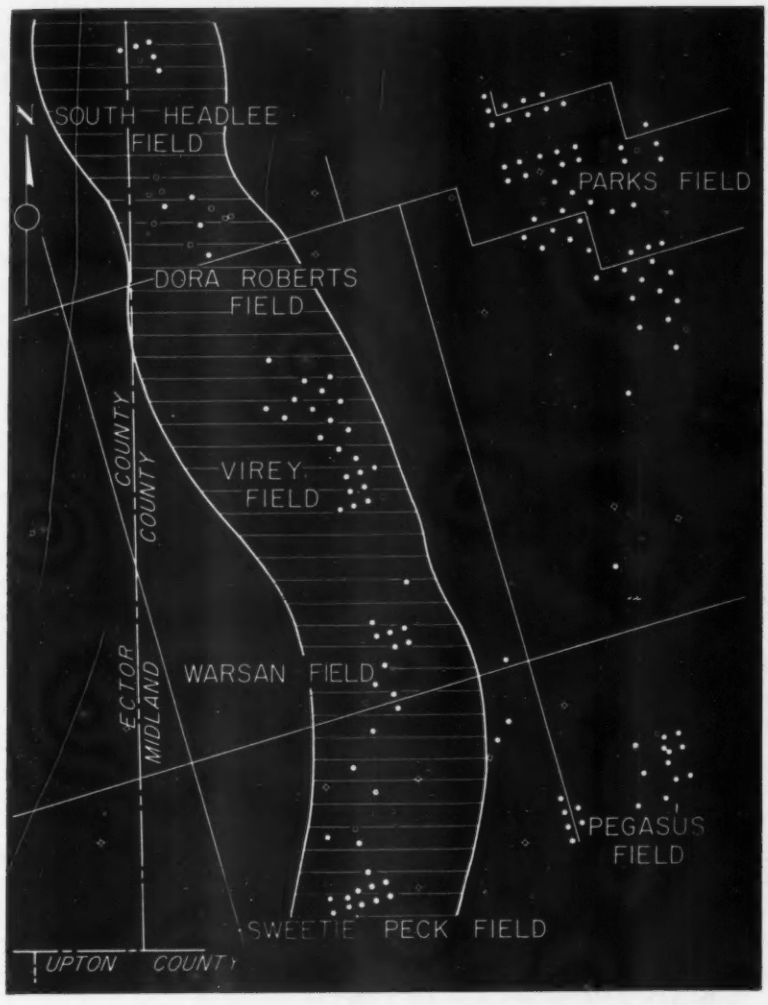


FIGURE 1—This is the Headlee, Dora Roberts, Warsan trend of West Texas where they are . . .

Controlling Crooked Holes

. . . by using large OD drill collars, correctly placed stabilizers, proper drilling practices and the Woods-Lubinski data.

By H. M. ROLLINS
Drilco Oil Tools, Inc., Midland, Texas

RESULTS OBTAINED from classifying drill collars and bottom hole assemblies for crooked hole studies together with the theoretical studies of Woods and Lubinski[1,2,3] have been so encouraging that it was felt that further studies were warranted. An area where recent drilling had utilized these theories and practices was chosen.

In Midland and Ector counties there have been 110 wells drilled to total depths of 13,000 feet in the last three years. These wells were drilled in the Headlee, Dora Roberts, Virey, Warsan Trend. See Figure 1. A survey of these holes using the same principles which were utilized by Brantly and Moore in their survey of the Russel field[4] was made.

In discussing the Headee-Warsan survey, people who were familiar with the area, commented that they did not consider the area to be a crooked hole zone. For the record: 29 wells were drilled without reaching a deviation of 3 degrees. Thirty-three wells reached maximum deviations between 3 and 4 degrees. Forty-eight wells reached maximum deviation in excess of 4 degrees with one well reaching the maximum deviation of eight degrees and being plugged back.

Using the same drill collar and bottom hole classifications which Brantly and Moore used, results of this survey are plotted in Figure 2. Drilling rates are shown for the interval between 6000 feet and total depth. Notice that a good bottom pendulum assembly is required to qualify for a fast drilling rate. Those holes drilled with poor bottom assemblies have poor penetration rates.

The Warsan and Virey fields in the south end of this area present special drilling problems because of lost circulation in the upper sections and high pressure gas and sloughing shale in the lower sections. In many wells, a 7⅝-inch liner is set in 8¾-inch hole at 9000 feet, and a 6¾-inch hole is drilled to total depth. The Warsan-Virey area wells are shown by the star symbol; the Headlee-Roberts wells by the solid symbols.

Although there is about two ft./hr. difference in drilling rates in the two areas, use of good bottom assemblies is confirmed as good practice in either area. The contractor who can maintain an acceptable hole angle while carrying 5000 to 8000 pounds per inch of bit diameter will drill faster than those who must carry only 2500-3000 pounds per inch in order to keep the hole angle small.

In this Headlee-Warsan survey an attempt has been made to correlate crooked hole conditions in relation to structure of the field. With the exception of those holes which drilled into faulted zones, there is no apparent correlation of position on the structure and crooked hole condition. Any hole drilled in these fields could have been a crooked hole.

In Figure 3 the frequency of maximum deviation vs. depth is plotted. Many of the holes entered the Devonian formation at approximately 11,000 feet and there was a tendency

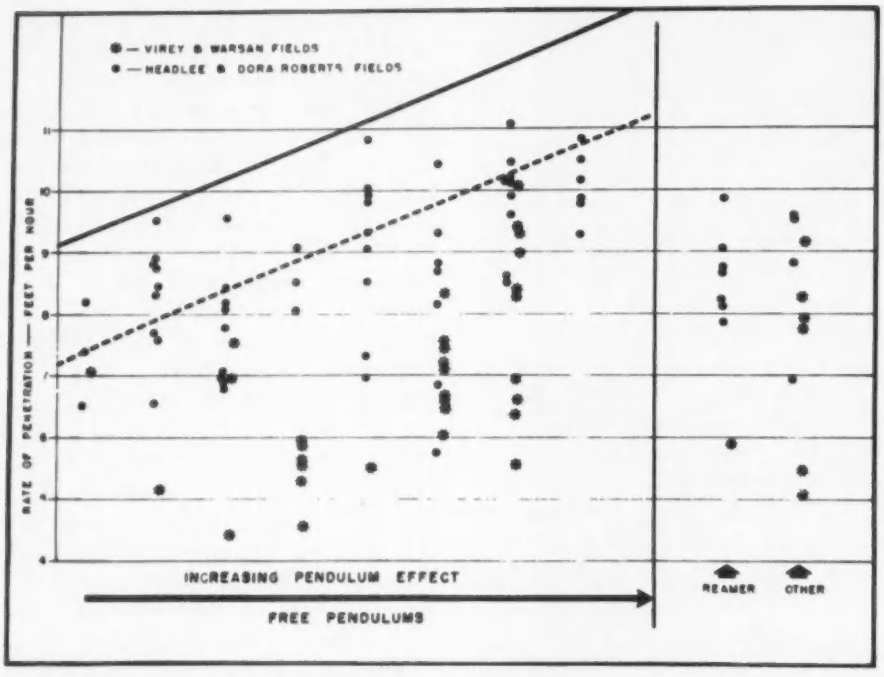


FIGURE 2—Plotted results of the Headlee-Warsan survey. Drilling rates are shown for interval between 6000 feet and total depth.

to increase deviation rapidly and to reach maximum deviation at this point. From just above the Ellenburger section to total depth a similar increase in deviation was noticed.

There has been a successful technique used for drilling into a zone where it is anticipated that crooked hole trouble will be encountered. This is to use the stiffest bottom hole assembly possible under existing hole conditions. This frequently is done by placing a reamer immediately above the bit, then a large diameter drill collar and a stabilizer or string reamer at the top of this first drill collar. Such an assembly minimizes the pendulum effect, but permits penetration into a crooked hole zone with a gradual increase in deviation. Ultimate build up of hole angle would be extreme with this bottom hole assembly. However, if the crooked zone is not too thick it is possible to drill the zone before the maximum allowable deviation is reached.

This survey indicates not only that the "good bottom assembly" theory is sound but also that it is being utilized by many drilling contractors in the West Texas Permian Basin area. These theories have been used in other areas, to the advantage of producing companies as well as drilling contractors. The Straight Hole Committee summarized a paper prepared by one of the major oil companies describing development drilling in a field in north central Texas in which this company had compelted approximately 65 wells below 5400 feet.

The first ten wells were drilled by two drilling contractors following the cenventional practice in that area in 1953. This was to drill an 8¾-inch hole with 6-inch drill collars and no stabilizers. A maximum deviation of 3 degrees was specified to the contracted total depth which ranged from 5400 to 7200 feet.

After the first ten wells were drilled, a conference was held between oil company representatives and representatives of the two drilling contractors. It was decided that the 3 degree deviation clause was an important factor in the cost of drilling in this field. The field is a typical anticlinal structure with moderate faulting and fairly flat formations down to a depth of 5500 feet. Below 5500 feet, formation dips are approximately 12 degrees near the crest of the structure increasing to more than 55 degrees on the flanks.

It was agreed that the oil company would modify its hole deflection tolerance to 1 degree per 1000 feet, rather than asking for 3 degrees maximum deviation to total depth. The contractors agreed that they would alter their operating practice—one contractor using 7½-inch drill collars as his bottom assembly in 8¾-inch hole; and the other contractor by using jet bits and drilling a 7⅞-inch hole with 6-inch collars.

After each contractor had drilled approximately six more wells, with encouraging results, it was decided to combine the use of jet bits and oversize drill collars. From this point, the 7⅞-inch holes drilled in the field were drilled with either 6¾-inch or 7-inch OD drill collars as a bottom assembly and jet bits were used. The contractor drilling 8¾-inch holes continued to use 7½-inch drill collars and began using jet bits.

Figure 4 illustrates some typical deviations and weights on bit, before and after the liberalized hole deflec-

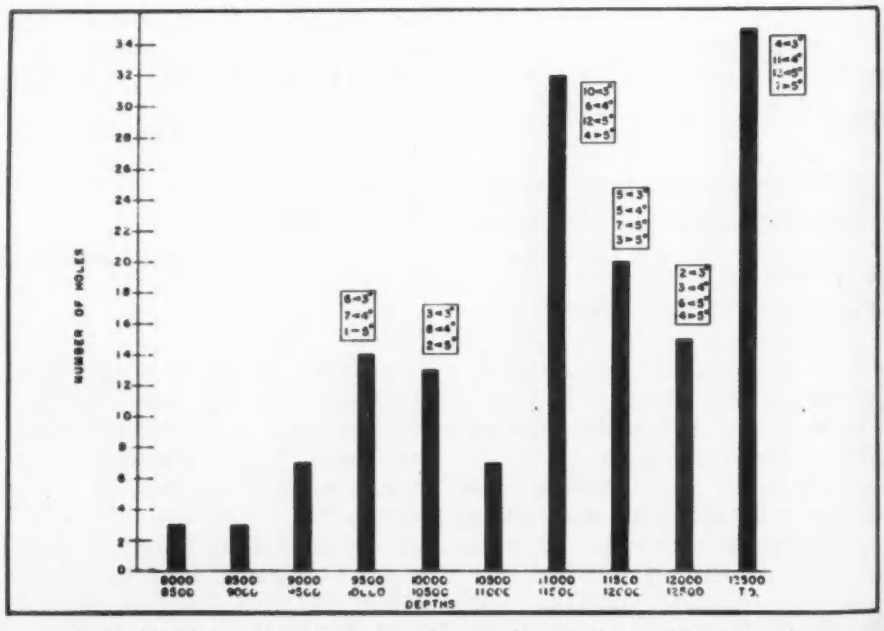


FIGURE 3—Distribution of maximum deviation holes in Headlee-Warsan trend.

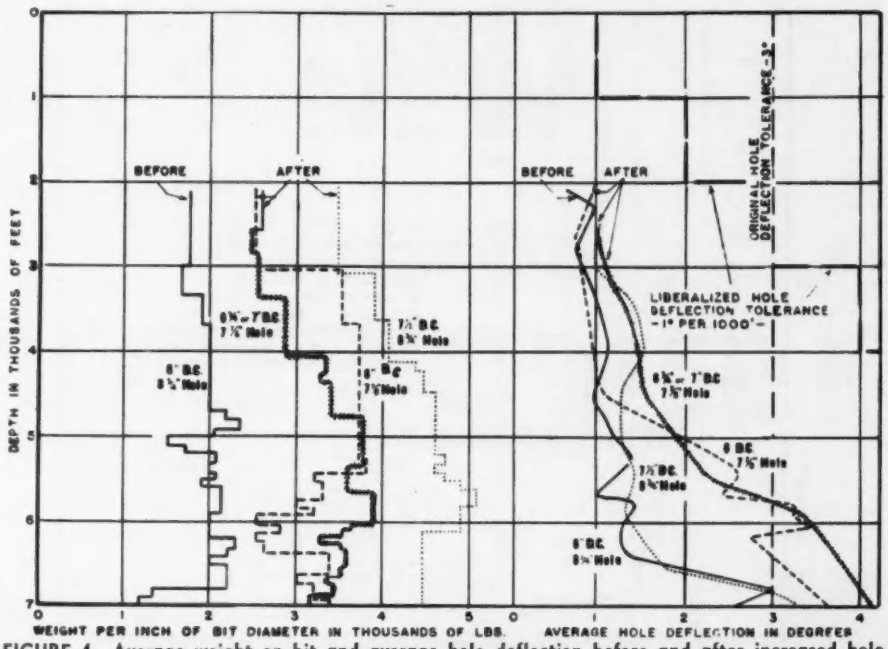
tion tolerance. After liberalization, and down to depths of approximately 6000 feet, average hole deviation did not exceed the specified 3 degree limit even though considerably heavier weights were used in drilling. Although greater deviation was experienced, changes in hole deflection were generally much more gradual in holes drilled with large diameter drill collars and heavy weights than they were in the holes drilled with small diameter drill collars and light weights.

Thus, by liberalizing the hole deflection tolerance, very definite encouragement was given to the contractors to use heavier weights. The result was that penetration rates were much greater and changes in hole angle were less severe.

Figure 5 is a plot of net drilling days vs. depth for the wells in this field. Before introduction of increased hole deflection tolerances, jet bits and oversize drill collars, average drilling time to 7000 feet was 39.5 days. By the change in drilling practices, drilling time was reduced to an average of 23 days; a 42 percent reduction.

Considering each technique individually: In those holes drilled with 7½-inch drill collars and 8¾-inch conventional bits, drilling time was cut to 22 days; and with jet bits, to 21.5 days. In those holes drilled with 6-inch drill collars and 7⅞-inch jet bits drilling time was reduced to 25 days, and with 6¾-inch or 7-inch drill collars and 7⅞-inch jet bits, to 22.5 days.

Approximately 12 days of the overall average reduction were credited to relaxation of the deflection limitations. Use of large drill collars accounted for the largest portion of the remaining 4.5 days. Use of jet bits added little to the over-all time reduction. This is attributed to the fact that only a very limited hydraulic horsepower was available with the rigs used.


DEPTH IN THOUSANDS OF FEET
BEFORE
AFTER
BEFORE
AFTER
ORIGINAL HOLE DEFLECTION TOLERANCE - 3°
LIBERALIZED HOLE DEFLECTION TOLERANCE - 1° PER 1000' -
WEIGHT PER INCH OF BIT DIAMETER IN THOUSANDS OF LBS.
AVERAGE HOLE DEFLECTION IN DEGREES
FIGURE 4—Average weight on bit and average hole deflection before and after increased hole deflection tolerance.

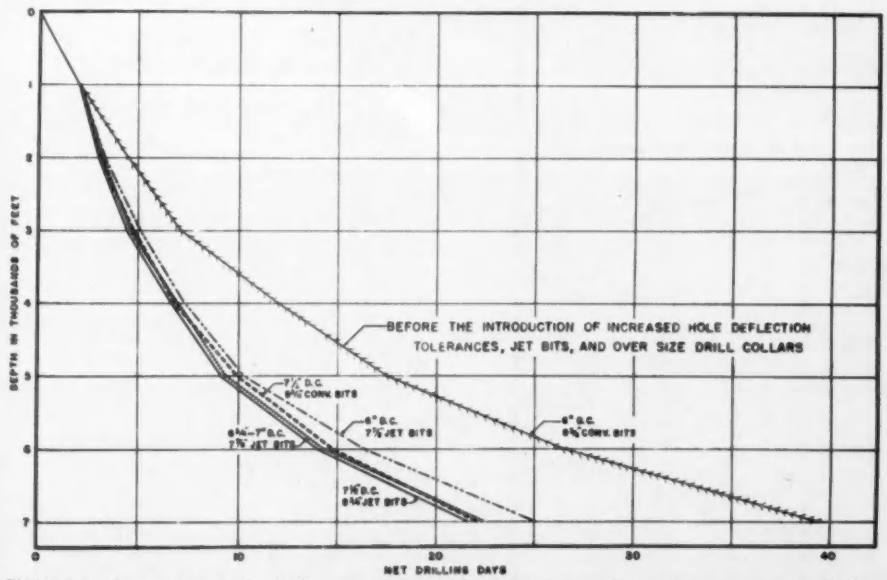
It is interesting to note that in drilling approximately 45 wells in which oversize drill collars were used, and in an area where there were steeply dipping formations, troublesome key-seats were experienced in only two wells. The resulting fishing jobs were simplified since 10¾-inch surface casing permitted reaming down to the drill collars.

These surveys illustrate the usefulness of the available theoretical information. They also demonstrate that crooked hole problems are more generally understood than they have been. Still it is not to be assumed that the problems of drilling in crooked hole zones have been compltely solved.

Figure 6 illustrates a well drilled southeast of Monahans, in Ward County, Texas. A West Texas drilling contractor using what was considered to be good practice, 7-inch drill collars in 8¾-inch hole and a stabilizer placed at 60 feet, had a hole increase in deviation from 1 degree to 7 degrees in an interval of approximately 110 feet while drilling with 50,000 pounds. This hole was plugged back and redrilled three times because the bit kept turning back into the original hole. Eventually, the hole was deepened below the original plug back depth at 7 degrees, approximately the angle of the original hole.

In hindsight, it can be shown from theoretical considerations that with the best available tools, this was the result that could be expected. No equilibrium condition was reached in the original hole. In the whipstocked hole, equilibrium was reached at 7 degrees, with 4000 pounds using 7-inch drill collars and a stabilizer at 60 feet, assuming a 15-degree dip condition.

There is little chance of drilling this section at less than 7 degrees with presently available tools. Use of


DEPTH IN THOUSANDS OF FEET
BEFORE THE INTRODUCTION OF INCREASED HOLE DEFLECTION TOLERANCES, JET BITS, AND OVER SIZE DRILL COLLARS
NET DRILLING DAYS
FIGURE 5—By the change in drilling practices, drilling time was reduced to an average of 23 days —a 42 percent reduction.

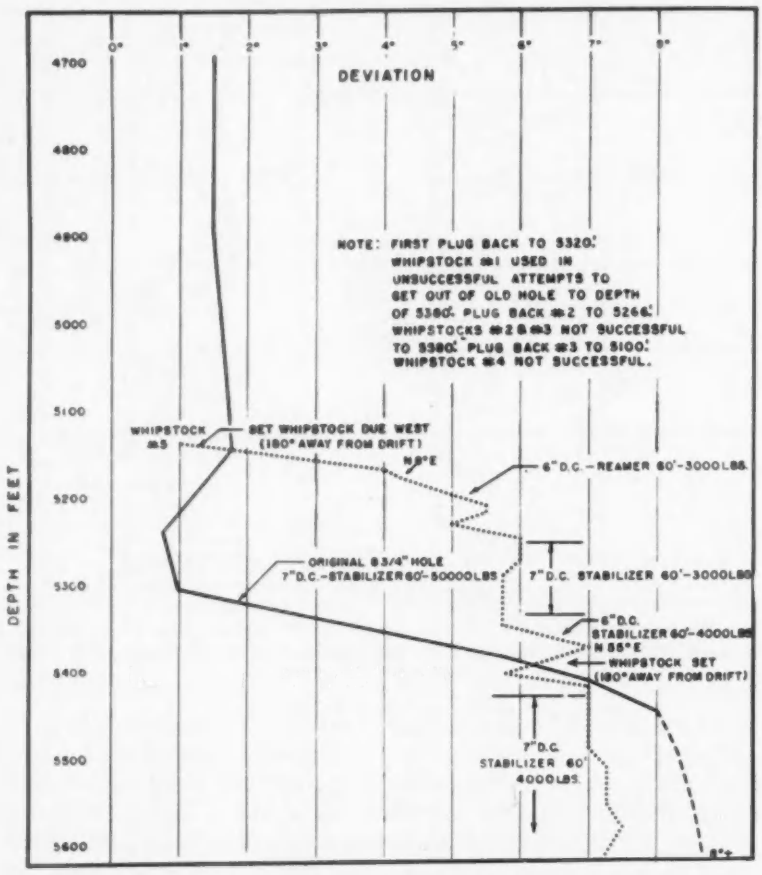


FIGURE 6—This well ran into real crooked hole trouble in Ward County. Hole was plugged back and redrilled three times because bit kept turning back into original hole.

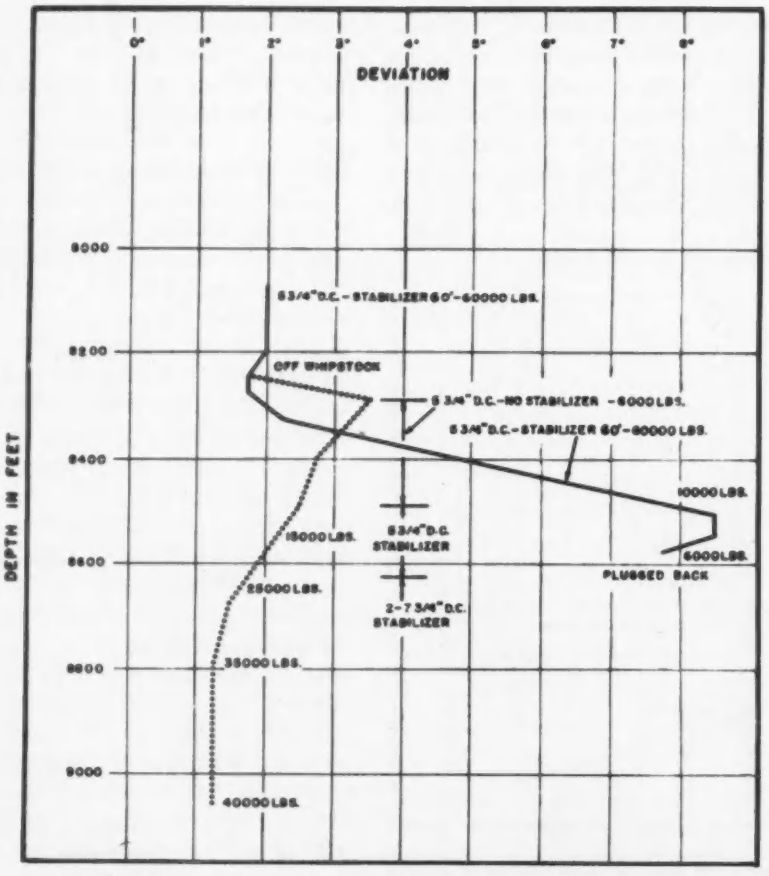


FIGURE 7—Extreme crooked hole illustration of Dora Roberts field.

a stiffer assembly might have permitted penetration through the zone with slow angle build up, if the zone had been anticipated.

In the survey of the Headlee-Warsan Trend there was one hole that reached a maximum deviation of 8 degrees at 8500 feet. It was necessary to plug back this hole. In redrilling this section, a maximum deviation of approximately 4 degrees was obtained, just off the whipstock, and through the zone of maximum build-up in the original hole the angle was actually reduced. See Figure 7.

The theoretical work of Woods and Lubinski would confirm the decision to plug back in this instance, since an improved bottom assembly could reduce the deviation appreciably. The original hole was held for about 50 feet at 8½ degrees with 10,000 pounds, and the angle was apparently reduced by use of 6000 pounds. In redrilling the section with two 7½-inch collars, a stabilizer at 63 feet, and a weight of 10,000 pounds, the calculations indicate a hole angle of 4 degrees should be maintained with a 15 degree formation dip assumed, which is reasonable for this location. Actually a smaller angle was reached.

The Woods and Lubinski data are very valuable tools which are the first specific tools available to evaluate a crooked hole zone. This information should be used to promote a recognition of severe crooked hole conditions and the limitations of current good practices under such conditions. A more general understanding of these limitations should result in more liberal handling of deviation limits with resultant lower well costs.

ACKNOWLEDGMENT

This article is an excerpt from a summary report for the API Southwestern District Study Committee on Straight Hole Drilling presented by H. M. Rollins, Drilco Oil Tools, Inc., Midland, Texas, at the Annual API Southwestern District Convention in Fort Worth, March 23, 1956.

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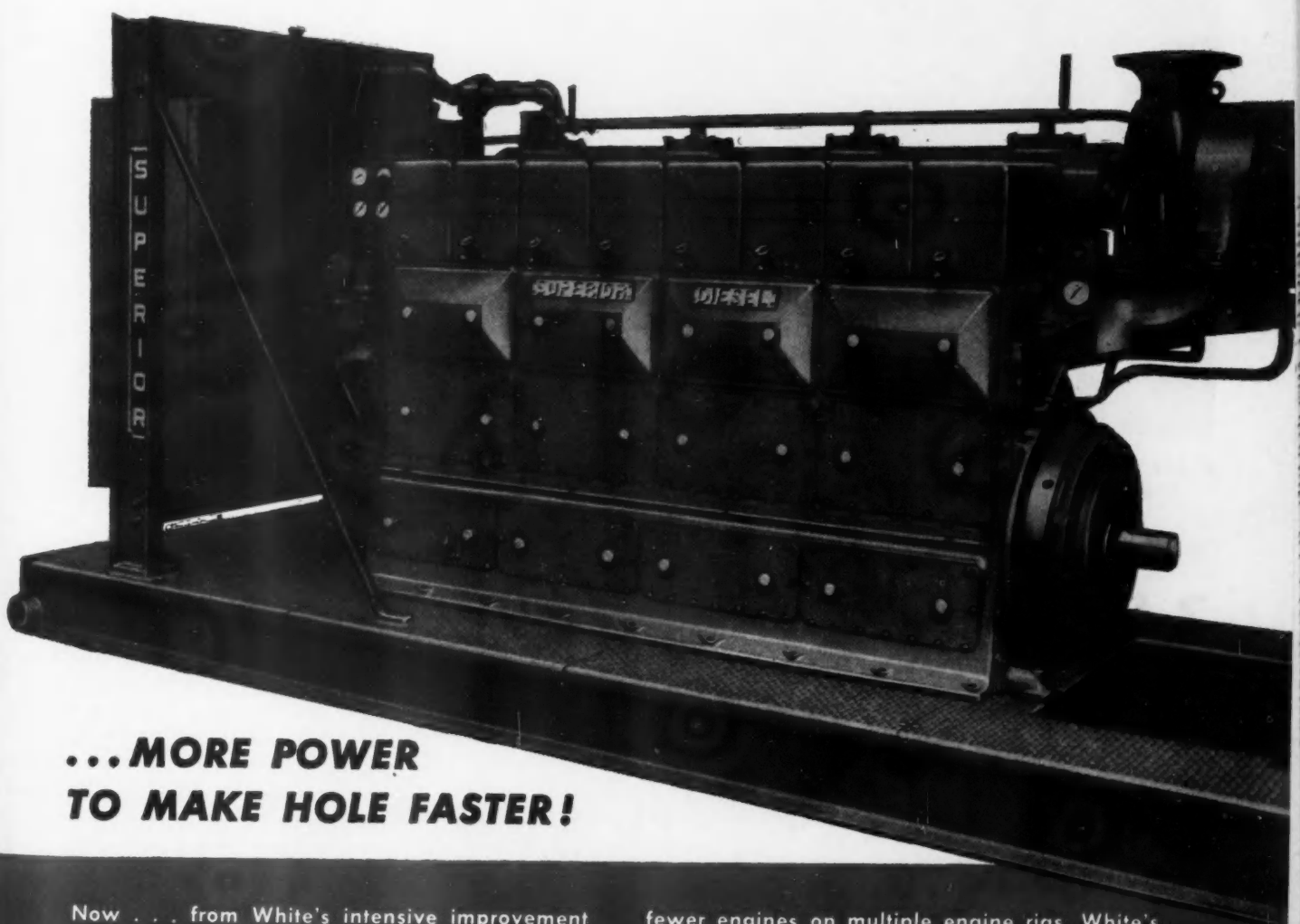

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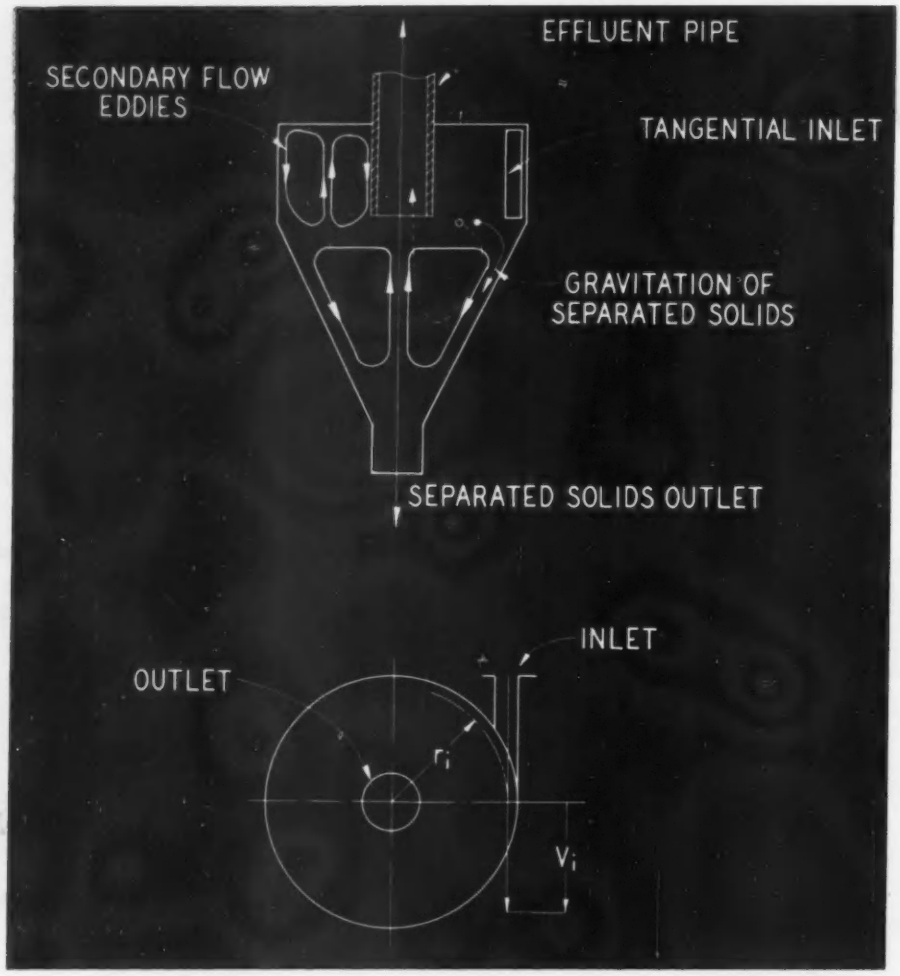

FIGURE 1—This three-inch ID cyclone promises to save money in the removal of drilled solids from unweighted muds or in recovery of barite from high density systems.

3-Inch ID Cyclone Removes Solids from Drilling Fluids

It's portable, inexpensive and easy to operate.

By W. E. BERGMAN, C. J. ENGLE, S. J. MARWIL and M. R. TEK
Phillips Petroleum Company, Bartlesville

AN IMPORTANT item contributing to drilling fluid cost is the need to discard a portion of the fluid as drilled solids accumulate in the system. This report shows that a 3-inch inside diameter liquid cyclone holds much promise for removal of drilled solids from unweighted muds or for recovery of barite from high density systems. Considerable savings may thus be made in the requirement for new mud.

The equipment employing the cyclone should be easily portable, inexpensive and simple to operate. Additional development work in the field and laboratory is planned.

The cost of drilling fluids is affected by many factors. The volume of the drilling fluid which must be discarded in order to remove the accumulated drilled solids becomes especially important when weighted muds are used. For the disposition of drilled solids in the mud, continuous dilution and intermittent jetting of drilling fluid is often required. While the amount of dilution may vary widely, 10 percent per day for a 500 to 1000 barrel system is probably not far from average.

Obviously, if the amount of dilution and hence requirement for new mud is reduced, substantial savings may be made. Various procedures which might merit consideration for this purpose were reviewed. Reports on practical applications of the liquid cyclone, together with a critical evaluation of the fluid and particle dynamics involved, indicated that centrifugal forces in a suitable cyclone would be sufficient to separate barite from the drilled solids (clays) dispersed in the mud.

This report summarizes the principles involved in operation of the cyclone and presents results obtained during pilot scale tests with laboratory-prepared and field muds. The tests with water-base muds were designed to test potentialities of the cyclone for:

- Removal of drilled solids from unweighted muds, and
- Recovery of barite from weighed (high density) muds.

In the first case, the effective removal of clays or drilled solids would permit recovery of a liquid phase with its attendant chemicals. In the second case, the barite frequently constitutes the major item of cost and its recovery would effect substantial savings. In addition, low solid muds may be maintained to achieve high penetration rates.

Fluid Dynamics of Cyclone Separation. The hydraulic cyclone, just like the centrifuge, is essenitally based on the principle of creating a centrifugal force field to effect the separation of solid particles. However, while it does not have any moving parts, it does have high specific mass transfer capacity plus satisfactory overload response, and it is simple in construction and operation.

For a basic understanding of the principles involved in the operation of hydraulic cyclones, a brief description of the cyclone will be given together

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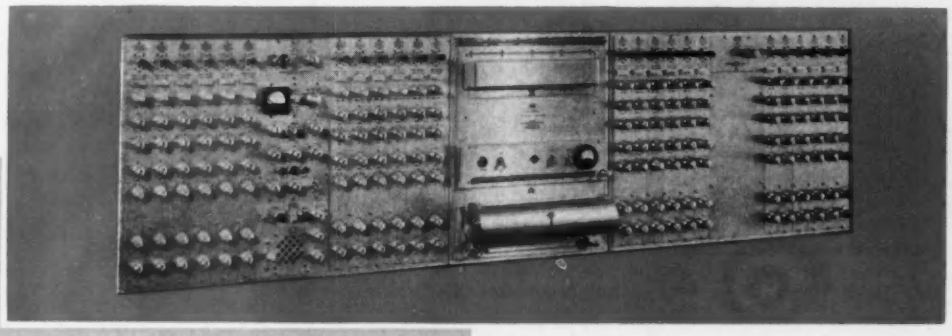

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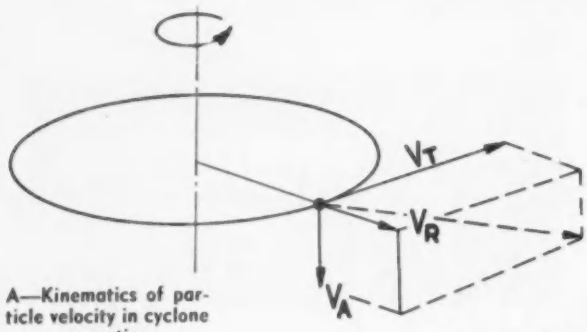
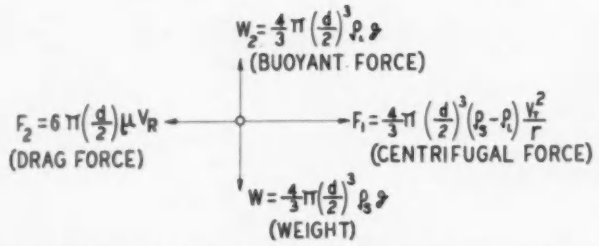


A—Kinematics of particle velocity in cyclone separation.



B—Forces acting on a spherical particle. In the above expressions, d is particle diamater, μ is viscosity, ρ_S—ρ_L are the densities of solid and liquid, V_T and V_R are tangential and radial velocities, and r is radial distance from cyclone axis.

FIGURE 2

with a brief consideration of the fluid and particle dynamics. As shown in Figure 1, the cyclone consists of:

- A cylindrical separation chamber into which the feed enters tangentially.
- A conical gravitation section.
- A central underflow or sludge discharge.
- A central overflow.

When the feed is introduced into the cyclone tangentially, the fluid acquires a vortex motion due to the principle of conservation of angular momentum. In the centrifugal field developed, particles of high settling velocities are thrown to the quiescent boundary layers where they gravitate down along the stationary side walls.

The main flow pattern through the cyclone separator is given by a double vortex with a large diameter vortex spiraling down on the outside and a smaller diameter vortex spiraling up on the inside.

The existence of the strong centrifugal field creates a number of eddies as shown in Figure 1. Depending upon their location and nature, these secondary motion eddies are sometimes helpful in the separation process by dragging the separated solids down into the sludge discharge.

Figure 2 represents the kinematics of a particle during cyclone separation. The velocity components as indicated in Figure 2 are radial, tangential and axial. The velocity distribution results from the interplay of forces acting on the particles. The bottom half of Figure 2 gives equations relating to forces acting on a particle in the cyclone.

The separation process depends on the centrifugal force which is proportional to the square of the tangential velocity. The tangential velocity distribution is given on Figure 3. The centrifugal force field is fairly effective within the solid-body rotation zone, highly effective in the separation or forced vortex zone and low in the settling zone. From the quantitative formulation of the centrifugal force or the local acceleration, the number of *g*'s developed within the cyclone separator increases from zero at the stationary wall to a maximum at some intermediate point between the injection radius and cyclone axis. For the particular cyclone used during the experiments the centrifugal accelerations developed for the experimental conditions were calculated to be in the range of 600 to 500 *g*'s.

Experimental. The installation for testing the cyclone is shown schematically in Figure 4. It consisted of a

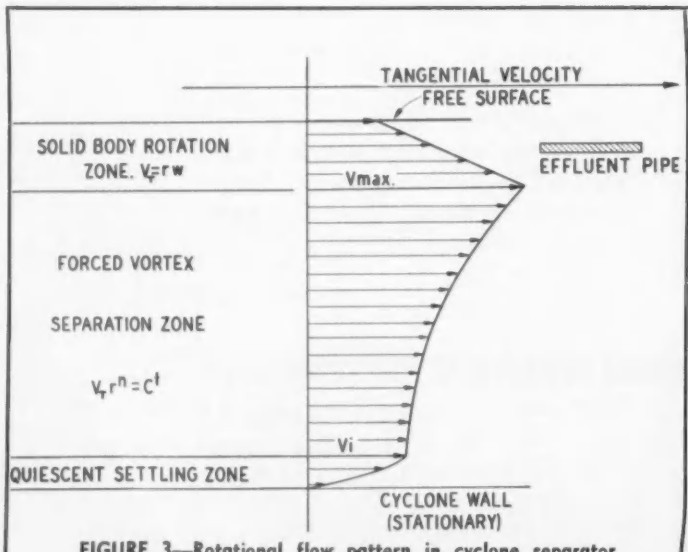


FIGURE 3—Rotational flow pattern in cyclone separator.

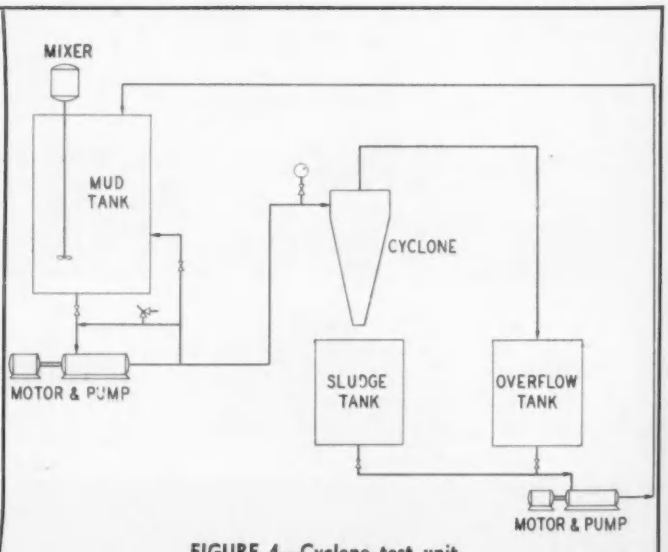


FIGURE 4—Cyclone test unit.

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100 gallon tank for mixing and storage of mud, a pump with motor for circulating mud to the cyclone, sludge and overflow tanks mounted on scales to permit mass-flow measurement, and a recycle pump. For operation, flow was started through the cyclone, and the pressure drop or flow rate across the cyclone was adjusted by the by-pass valve. Samples of the feed, overflow and sludge were collected during the test.

The following data were obtained on the samples: density of the fluid streams; percent solids by weight in the fluids; and density of the solids. In the case of weighted muds, the density of the solids was taken as a direct measure of the percent by weight of barite in the solid phase.

The cyclone used for the tests had a cylindrical section which was 3 inches in diameter and 2 inches long. The cone section had a 20-degree angle. The area of the rectangular feed orifice was adjustable from about 0.1 to 0.5 square inches. The orifice for the vortex finder (overflow pipe) and for the sludge discharge could be varied from 0.03 to 2.0 square inches. By proper selection of orifice sizes, the ratio of the overflow to underflow could be varied over a wide range for a given rate of flow through the cyclone.

Results and Discussion. Consideration of the centrifugal and gravitational principles involved in flow through the cyclone indicated that many factors might affect the separation efficiency. For example, the separation basically depends on the physical properties of the continuous and dispersed phases, on the geometry of suspended particles, design characteristics of the separator and the dynamic characteristics of the flow system.

It was not intended that the exploratory work would accurately evaluate the effects of these factors. Rather, it was intended only to demonstrate whether the liquid cyclone had sufficient merit to justify more intensive study or field testing. Since the results have been encouraging, a brief summary is reported now.

Results obtained with three unweighted muds are reported in Table 1. For these tests the flow through the cyclone was maintained at a rate of about 27 gallons per minute with cyclone inlet pressures of 120 to 125 pounds per square inch. Tests (not reported here) showed that for the experimental conditions, inlet pressures of about 60 psi gave a maximum removal of clay when expressed as pounds of clay in the sludge (underflow) per pound of clay in the feed. However, as the pressure increased above 60 psi, the feed rate increased so that the capacity (tons per day) of the cyclone increased. While the muds fed to the cyclone had density of 9 to 9.6 pounds per gallon, the sludge densities were 12.2 to 12.8 pound per gallon. It would appear from these results that the sludge density was not highly dependent upon the type of mud. However, the type as well as size and shape of the clays present in the mud may affect the operation of the cyclone.

Most clearly apparent is the ability of the cyclone to remove tonnage amounts of clay per day from these muds. This, in turn, may be expressed as percentage savings in dilution. These latter values fall in the range of 74 to 90 percent and approximate the decrease in requirement for new mud resulting from use of the cyclone.

TABLE 1
Separation of Clay or Drilled Solids From Unweighted Muds Using the Three Inch Cyclone

	Mud 1	Mud 2	Mud 3
Flow rates, gpm			
Feed (at 120-125 psi)	27.3	26.3	26.7
Overflow	26.1	23.1	25.2
Sludge	1.2	3.2	1.5
Density, lb./gal.			
Feed	9.6	9.6	9.05
Overflow	9.45	9.2	8.75
Sludge	12.55	12.2	12.8
Solids content, weight percent			
Feed	21.5	21.5	12.0
Overflow	19.2	15.2	7.8
Sludge	55.5	51.6	57.0
Solids removed in sludge			
Pounds/pound in feed	0.15	0.37	0.38
Tons/day	6.03	14.4	7.8
Dilution savings, percent	78	74	90

TABLE 2
Recovery of Barite Using the Three Inch Cyclone

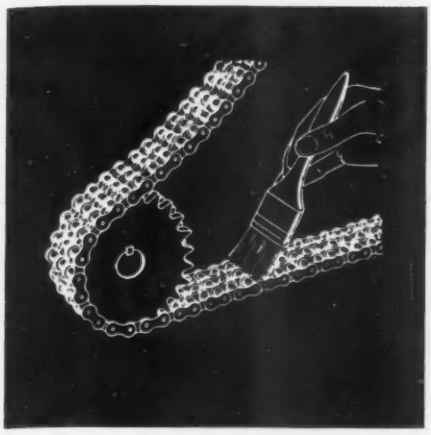
	Mud 1	Mud 2	Mud 3
Flow rates, gpm			
Feed (at 125-150 psi)	29.9	29.9	29.6
Overflow	27.3	25.0	22.6
Sludge	2.6	4.9	7.0
Density, lb./gal.			
Feed	10.3	10.3	10.5
Overflow	9.3	9.2	9.0
Sludge	21.5	16.3	17.9
Solids content, weight percent			
Feed	26.6	27.1	26.5
Overflow	15.3	14.0	10.8
Sludge	78.0	65.8	69.4
Weight percent $BaSO_4$ in			
Feed	58.1	58.5	91.5
Overflow	21.4	16.6	76.5
Sludge	90.4	85.0	97.8
$BaSO_4$ recovered			
Lb./lb. in feed	0.795	0.890	0.805
Tone/day	28	32	44

For high density muds, attention is focused on recovery of barite, since the major cost of those muds may be due to the barite. By the jetting now practiced in the field, this barite is lost to the reserve pit. For the tests reported in Table 2, high density muds were diluted to 10.3 to 10.5 pounds per gallon prior to cyclone treatment. About 80 to 90 percent of the barite in these muds was recovered as a sludge having a density of 16.3 to 21.5 pounds per gallon. The purity of the barite in the sludge varied between 85 and 98 percent. For the test conditions, the barite was recovered at rates of 28 to 44 tons per day.

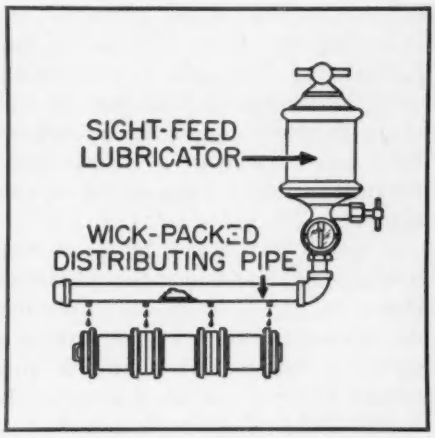
Purity and percentage recovery of the barite are emphasized in this type of application for the cyclone. For any separation based on centrifugal and gravitational forces, these two factors oppose each other in that factors which increase the recovery may decrease the purity. Other tests with the cyclone have demonstrated that when the feed rate is held constant, the percentage recovery decreases with increase in ratio of the overflow to underflow volume.

The purity of the barite in the sludge increases as the ratio of overflow to underflow increases. With spray-type discharge from the cyclone recoveries in the range of 75 to 90 percent may be obtained readily with most muds, and the purity will be 85 to 90 percent. With rope-type discharge, the barite may be obtained as a sludge having a density of about 24 pounds per gallon. The recovery may be low—in the range of 50 to 80 percent—but the purity will be above 95 percent.

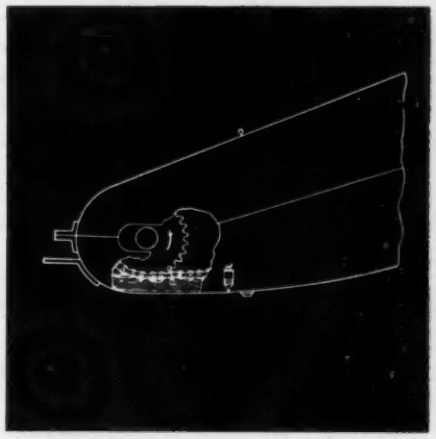
While the experimental work with the cyclone is far from complete, these results are very encouraging. The cyclone merits serious consideration for recovery of barite as well as for removal of drilled solids. More extensive testing and development, especially with field muds, is planned in order to exploit the potentialities and define the limitations. The equipment necessary for field tests should be easily portable, relatively inexpensive and simple to maintain and operate. **—The End**



1 Periodic or manual lubrication is accomplished by applying oil with a brush, or by spout can. Use SAE 40 oil and apply to the inside of the chain at the edges of the side plates. Revolution of the chain will carry oil to all working surfaces. Regulate amount so that entire chain is lubricated but none thrown off. Twice a week is usually enough for the average drive, but frequency should be checked by periodic inspections.



2 Drip feed lubrication consists of a sight-feed lubricator feeding through a wick-filled pipe. (Pipe cleaners make ideal wicks.) Oil should be delivered to the upper edges of the side plates on the lower strand —near where the strand engages with the sprocket. Regulate rate to assure complete lubrication without flooding. The chart indicates recommended oil grades and minimum feed rates.



3 Dip, or bath lubrication is superior and requires less attention than drip-feed. Lower arc of chain is led through a bath or pool of oil which is kept at about the chain pitch line. A chain guard is required to prevent the loss of oil and splash. For high speed drives, use oil-tight cases. Use an SAE No. 30 oil. Add oil as necessary to maintain oil level. Drain and clean the housing and replace oil once a year, or oftener if needed.

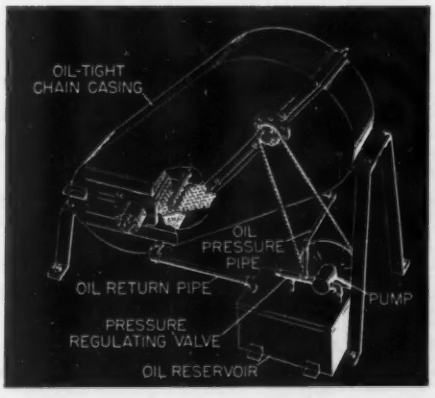
Don't Neglect Your Power Chains

Improper installation and poor maintenance practices can cost you money. Here are some good points to remember.

By DAVID BREITH
Chain Belt Company of Milwaukee, Wisconsin

POWER OR DRIVE chains on a drilling rig usually are covered and, therefore, seem to receive less attention than their importance and cost warrant. Proper installation and alignment, frequent checks and proper lubrication can result in long and efficient chain life. Chains should be given the same consideration and attention that other important parts of the rig receive.

From the time a drilling rig, be it rotary or cable tool, arrives at its first location, the supply store's display yard or the contractor's yard, an initiation by the elements begins that will surround it during the lifetime of the equipment. The dust that blows into and onto all exposed parts makes its way into almost airtight chain cases and bearings. When the rig is placed in operation, practically all equipment, excluding the engines, are exposed almost completely to rain, dust, dirt, cold and hot weather. Some of the elements do find their way into the best of enclosed rigs.



4 Copious or force feed lubrication is required for high speed, heavy-duty drives. Oil, supplied under pressure by a pump, is sprayed onto the chain, and excess is returned to the pump sump. An oil-tight casing is required. Use a heavy oil—about SAE 40—for most cases. Clean the system and renew the oil once a year, or oftener if needed.

Although these things are elementary, it is a good thing to review them occasionally as most everyone can overlook them in the everyday operation of drilling equipment.

It stands to reason that an occasional cleaning of the oil sump, of the oil bathed chain cases, of the compound cases between the engines, and of other depositories of chain lubricating oil should be as important to the drilling contractor as checking alignment of his derrick, pump or other equipment. It should be remembered that one of the "musts" for lubrication of chain is that a good grade of clean oil must be used. Crankcase drainings are harmful to the chain and should not be used.

Lubrication is a familiar word used

daily. But all too often a person is inclined to think of lubrication as "putting oil on it." That can be as false a lubrication as can be. All too often "putting oil on it" does not result in "getting oil into it."

Wherever metal bears on metal, forming a bearing surface, friction starts to rob. It robs power, efficiency, and life of the bearing. Every piece of chain is made up of a series of bearings. Every link, or pitch, has bearing surfaces between roller and bushing, and between bushing and the pin. It is vital to good chain life that this thought be uppermost when thinking of chain.

Therefore, lubrication becomes a major factor in chain life, as it does to any other type of bearing. Get oil into it to form a protective film between the metal surfaces to reduce friction.

There are various ways to obtain proper chain lubrication. First to be considered are the variable factors that act as a guide to selection of a proper lubrication method that will be best suited to the particular drive or drives under consideration.

Start at the rotary table and work back through the rig. Whether the rig is a conventional type derrick or a portable, Jackknife-type mast, several factors must be considered. Can an oil-tight, oil bath chain case be installed, and if so, will it be practical? What could cause it to be impractical if it will result in better lubrication and longer chain life?

If the rig is operating in an area where there is only shallow drilling, where time on each location is very short, and the rig is intended to remain in that area during its operating life, an oil bath chain case might be impractical. If the speed of the rotary table is constantly low, use of an oil bath case might not be of too great merit.

The next question of lubrication is: What weight oil should be used? The easiest answer is: Use the same weight oil for chains as would be used in an automobile. The cost of chains on a drilling rig can easily approach the cost of a car. If they are not treated with respect and given proper care the cost can be higher.

The next thing to think about is how to get the oil into the chain on the rotary drive. If an oil bath chain case is used the oil level in the chain case, at its lowest point, should reach a point on the bottom strand of the chain slightly above the head of the pin or rivet. This will keep the chain well lubricated. The friction of the chain passing through the oil will be held at a minimum; thus holding foaming action of the oil at a low degree.

If an oil bath case is not used then a lubricator should be mounted on the chain guard, or some where on the drawworks close to the driving sprocket. An oil line should be run from it to a point between the strands of the chain. The line should be just above the bottom strand so that the oil will run into the chain at a point near the sidebars just before the chain enters the driving sprocket.

If the oil is so directed into the chain, action of the rollers and bushings will approach that of an oil pump. They will force the chain to oil all its working parts, between the rollers and bushings, and between the bushing and the chain pins or rivets. When oil is dripped onto the top strand of the chain it is mostly thrown away from the working parts by centrifugal force before it can enter into the chain and be effective.

A lubricator and feed line, as recommended, can be easily and inexpensively built and installed by almost any oil field welder, or by the crew itself.

Chain drives within the drawworks of modern design are enclosed in oil bath chain cases. The oil level should be kept to the specified level as indicated by the rig manufacturer. In most cases of this type, an oil-level inspection plug is provided. For those rigs that do not have oil bath chain cases a lubricating system built along the same principles as outlined for the rotary drive should be used. The oil should be run into the chain at a point on the drive so that oil enters the inner strand as it enters one of the sprockets.

Oil can be used too sparingly, and by the same token, too effusively. Enough oil should run into the chain to keep it well oiled, but not enough so that it would run off and be wasted. Naturally, oil should not be run into idle chains. A shut-off should be handy to stop oil flow to the inactive drives when drilling ahead.

TABLE 1
Recommended Oil Grades and Feed Rates

Chain Pitch	Drip-Feed		Fast-Drip-Feed	
	SAE No.	Drops per Min.	SAE No.	Drops per Min.
Up to ¾"...	30	2	20	8
1" to 1½"...	30	3	20	12
1¾" and up.	30	4	20	16

When the rig manufacturer has equipped the rig with an oil pump-spray lubricating system, frequent checks should be made to see that the oil pump is producing and maintaining proper pressure. Pump suction screen should be clear of sediment or foreign matter which might reduce pump volume and efficiency. Regular checks should be made to see that all oil lines are flowing freely, are not out of place, and are directing the oil to the chain in a manner specified by the manufacturer. Should a chain break and be replaced or repaired, oil lines should be immediately repaired or replaced and realigned.

Nearly all power rigs have oil-bath chain cases on the master input drive chain. In the rare case where this is not so, an oil-bath chain case should be built and installed. Drip oiling is not sufficient to take care of the chain speeds generally found in these drives. The majority of steam-powered rigs have been equipped by their owners with such a case. If not, a generous quantity of oil should be provided in this drive, and, as mentioned before, properly directed into the chain.

Multiple engine drives, where chain is used to compound between the engines, and to provide a power takeoff for either single or double slush pump drives, almost without exception are equipped with oil-bath cases; or are equipped with pump-spray lubrication. The same precautions should be taken on these drives as previously outlined for drives within the drawworks. These checks should be frequent, regular and careful. They are as important to operating overhead as the grease-up precaution so regularly taken.

The subject of lubrication is so important that considerably more space could easily be devoted to it, but the salient points have been touched upon. The drilling contractor, superintendent, toolpusher or driller can expand upon each point as needed. There is plenty of reference data available from petroleum products suppliers, public library, or from the American Association of Oilwell Drilling Contractors.

Maintenance Problems. As pre-

viously pointed out, there are many specific problems in the oil fields directly pertaining to care and maintenance of chains used in drilling and in well servicing work. Here is a review of some of these problems and the care and type of maintenance suggested for better service and longer life from chain dollars investment.

Again start at the rotary table and work back through the rig. The very nature of the action of the rotary table tends to twist itself out of alignment. The torque developed in turning the drill pipe through the kelly joint puts a considerable pressure against the chocks, blocks or bolts, that hold the rotary table over the center of the hole.

If that torque from the effort of "turning Toward Tulsa" were all that is involved, the problem would be a simple one. Far from it; as the hole drills deeper and the various geological strata are encountered, some will drill smoothly, some will bounce, jerk, buck, and kick.

What is happening to the chain that is driving the table? As the pipe kicks, jerks and bounces, the table receives the same treatment, but it is an action from side-to-side instead of the up-and-down travel of the pipe as it bucks. The chain is receiving snaps and jerks, overloads and racing action. Not a very pretty picture when the fatigue action that is created, is considered.

What to do about it? Run periodic checks to realign the sprockets on the drive, and at the same time, look for and replace all missing chain cotters. Look for cracked rollers, and for burred or peened sidebars. These may have been caused by banging against the sides of the sprockets, the chain guard or case; or if the chain is too slack, from slapping together in the middle of the drive span. Maintain proper slack, but not an excessive amount. About one and one-half pitch lengths of up-and-down movement on the slack or loose side of the chain drive, is a good figure to hold to. A chain that is running without slack, that is too tight for the drive, will wear itself out even with fair lubrication and with light or no loads. When checking alignment straightedge should be used, not eyesight alone.

The rotary counter-shaft drive, drive to the cat-shaft, low speed drive to the drumshaft, and high speed drive to the drumshaft, should get regular, though less frequent, checks for missing cotters, scarred or cracked rollers or sideplates. These should be inspected before rigging up on a new location. Alignment of the sprockets should be checked with a straightedge.

Drives within the selective-speed transmission should get occasional regular check-ups to replace missing cotters. Any section noted to have a bad looking place, such as cracked rollers, cracked or broken inner or outer sideplates, should be repaired.

A short-time repair can be made if a bad spot is noted upon inspection. If allowed to run until it breaks, additional shutdown time is involved in not only replacing or repairing the broken chain, but replacing and repairing oil lines, shifting mechanisms, air lines, etc. Cost of the parts is a lot less than cost of shutdown time.

A good time to check these drives could be at the time casing is set. This could be done at each cement waiting time and before the rig is placed in operation when making a location move.

The master input drive chain should be examined every time the rig is moved as well as at cement time. Condition of the sprockets and the chain should be noted carefully. Worn sprockets will eat up chain faster than any other cause other than misalignment.

Engine compound chains should be examined as often as those in the drawworks. The loads and shocks from drilling and hoisting through the drawworks, as well as those transmitted back from the slush pump, are travelling into and through these chains. All should be checked for the indicated signs, and additionally, for too much slack and wear.

Every time the slush pump is being worked on for any reason, such as checking valves and seats or changing liners or pistons, then is the time to look over the chain on the pump drive and repair if necessary. Pulsations of the rotary hose are greater back at the pump, and are transmitted up through the V-belts to the drive pulley and into the chain drive. These and the pulsations from the engines are going through this drive, back and forth, often causing a terrific snap on the chain.

Installation Check List. If a chain is not installed properly to begin with, it never will deliver maximum service. Check the following items at the time the chain is installed.

1. **Chain Selection.** Be sure you have selected the best type of chain for the service to be performed. If you are not certain as to the proper chain for your application, consult a chain specialist.

2. **Underchaining.** Be sure your chain is strong enough for the load it must handle. A drive which is overloaded 100 percent has about one-quarter the life of a properly selected drive.

3. **Shaft and Sprocket Alignment.** Proper alignment of sprockets and shafts greatly lengthens sprocket and chain life. To assure correct alignment:

Carefully level the shafts. With a multiple width sprocket, a spirit level can be applied across the teeth as shown. With a single width sprocket, use a machinist's level directly on the shaft.

Align shafts for parallelism, using a feeler bar. Recheck the level adjustment. Tighten all securing bolts and nuts to assure maintenance of the shaft alignment.

Align the sprockets axially on the shafts, using a straightedge. Take care to apply the straightedge to a finished surface on the side of the sprocket. For long center distances a stretched wire can be used instead of a straightedge.

With a shaft having some end play (as the shaft of an electric motor), align the sprockets with the shaft in its running position. To determine the running position, run the motor at operating speed, and scribe a line in the chalk opposite a convenient fixed point. Adjust the alignment with the shaft blocked in this position.

Secure each sprocket against axial end play by means of a set screw, or by collars set-screwed to the shaft. Do not depend on set screws to prevent the sprockets from turning on the shaft. Use keys.

4. **Chain Installation.** With the shafts and sprockets aligned, engage the chain with the sprockets and connect the free ends by means of a pin or connecting link. Do not make a hard job of it by bringing the free ends together between sprockets.

Proceed as follows: Remove the pin or connecting link; wrap the middle of the chain around one sprocket and

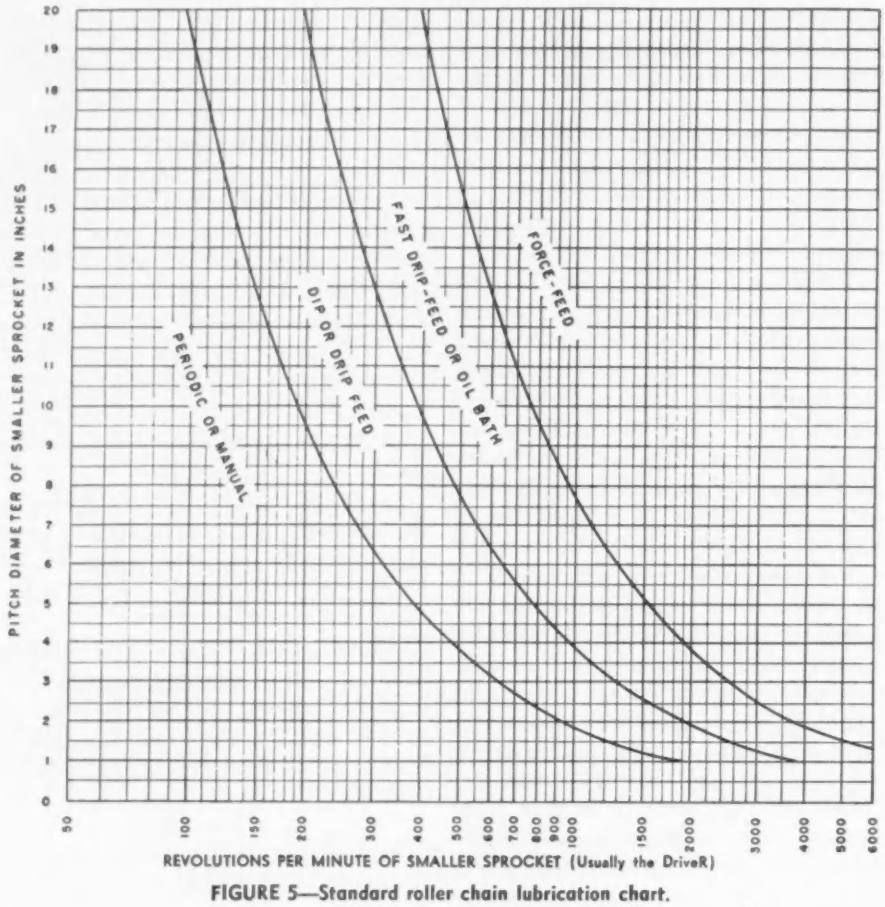

PITCH DIAMETER OF SMALLER SPROCKET IN INCHES
PERIODIC OR MANUAL
DIP OR DRIP FEED
FAST DRIP-FEED OR OIL BATH
FORCE-FEED
REVOLUTIONS PER MINUTE OF SMALLER SPROCKET (Usually the DriveR)

FIGURE 5—Standard roller chain lubrication chart.

engage the free ends with the teeth of the other sprocket; the sprocket will then hold the chain in place while the necessary pin or connecting link and pin are inserted. Pin is then held in place by cotter pin or spring clip.

5. **Chain Slack.** The correct amount of slack is essential to proper operation of chain. Unlike flat belts or V-belts, chain requires no initial tension and should not be tight around the sprockets. When chain is too tight, the working parts carry a much heavier load than is necessary and work much harder than properly installed chain. Thus, wear occurs much more quickly.

Too much slack also is harmful. On long centers particularly, too much slack will cause vibration and chain whip, reducing the life of both chain and sprockets. On exceptionally long centers it is recommended that the slack strand be supported by idler sprockets or hardwood strip.

6. **Proper Direction of Chain Travel.** For drives, the hook end of detachable, and the closed end of pintle or offset side bar chain, should lead, or travel forward. This relieves the load on the pin bearing when flexing on the driving sprocket, thus prolonging chain life.

Straight side bar chain operates equally well in either direction in both drive and conveyor service. Frequently additional life may be secured on rollerless chain by inverting the strands. Before this is attempted, a chain specialist should be consulted.

Dangers of Worn Sprockets. Chain cannot be efficient or durable if used with worn or faulty sprockets. It is, therefore, important to inspect sprockets occasionally for wear and alignment.

1. Be sure shafts are set parallel and level in rigidly supported bearings.

2. Sprockets must be mounted squarely and securely on their shafts.

3. Never run new chain on worn sprockets. When new chain is installed, never run it over sprockets with worn, "hooked" teeth. Hooked teeth tend to grab or hold the chain to the sprocket, an action which no chain can long stand.

4. Never run badly worn chain on new sprockets. Just as worn sprockets hurt good chain, worn chain will cause premature wear on new sprockets. If chain is "riding up" on the sprocket teeth and not seating properly, chances are that it's worn and the pitch is elongated. Once the pitch is elongated, sprocket life is appreciably shortened.

5. Sprocket reversal. Sprockets, if not too badly worn, can, in some cases, be reversed on the shaft and the opposite surfaces of the teeth used. But, it is always more economical to replace the sprockets than to replace the chain. When in doubt, consult a chain expert.

Relative Position of Sprockets. Relative poistion of sprockets in drives should receive careful consideration. Certain arrangements require less attention and care than others and are, therefore, less apt to cause trouble.

Other Arrangements. When the large sprocket is directly above the small sprocket, a drive cannot operate with much chain slack. As the chain wears, shaft center distance must be adjusted. With the drive slightly inclined, less care will be required because weight of the slack chain strand helps to maintain better contact between the chain and sprocket.

When center distances are short, or drives nearly horizontal, slack should be in the bottom strand. An accumulation of slack in the top strand may allow the chain to be pinched between the sprockets.

When small sprockets are used on horizontal drives, it is better to have the slack strand on the bottom rather than on the top. Otherwise, with an appreciable amount of slack, the strands may strike each other.

None of these lubrication or installation conditions are new to any contractor, superintendent or toolpusher. Yet, it is felt that they are all too often overlooked in the hurry of operations, and during the hundred-and-one things that are on their minds during each drilling day and night.

Drilling costs are higher due to much higher wages, higher cost of general rig supplies, higher tax and interest rates, and higher cost of all repair parts for equipment. Drilling footage prices have not changed much during the same periods that these changes have taken place. Therefore, every precaution for the smooth, continuous operation of equipment is a vital must for every interested member of a drilling organization.

It is felt that if the simple, yet common-sense, precautions and care which have been here recommended for chain drives, be followed, a lower operating cost certainly will result.

—**The End**

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Sieve Residue Logs

. . . provide a fast, simple and inexpensive method of obtaining valuable subsurface information without interrupting drilling operations.

By W. L. BUNING, Chief Paleontologist
United British Oilfield of Trinidad, Ltd., Trinidad, West Indies

A QUICK, simple and inexpensive method to follow closely the changes from clay into sand in unconsolidated rocks during drilling operations has been developed. The method is based on the plotting of the variations in volume of residue left on the screens by washing a standard quantity of cutting-sample through a set of three sieves. As sieve residue (S.R.) logs can also be used for zonal correlation it was found that the information obtained from these curves before the survey is conducted may occasionally contribute materially to the economy of drilling, especially in areas where subsurface conditions are confusing.

Although the S.R. logs have no exact quantitative value they nevertheless provide petrological information which is useful in conjunction with the electrical log, and which facilitates the interpretation of radioactive curves.

This article is written primarily for the man at the rig who wants not only the latest information but also a record of the variations in composition of the rocks being penetrated in his well. This is especially true in cases where the facilities of modernly equipped laboratories are not directly available. The simple method described herein may open a welcome source of subsurface information.

This procedure can be applied only on cutting material that is easily disintegrated. The results have been found fairly accurate and reliable as long as the screen samples collected are representative for the formation at the bottom of the hole. Many examples are known of striking similarity between residue and electrical logs. It is clear that due to the variations in quality of cutting material that the conclusions drawn from residue diagrams are of a tentative character only.

Purpose. A sieve residue log, when properly interpreted, gives an insight into the variation of the "sand" content of the rocks penetrated by the drill from the moment the well is spudded until the last foot is drilled. With this information, correlations can be made with neighboring wells. If necessary, the drilling program may be altered accordingly. In tectonically disturbed areas, footage may be saved by timely suspension of drilling, or the decision may be made to continue drilling before running an electrical survey.

Principle. The S.R. logging method is based primarily on the assumption that the quantity of loose grains present in a standard volume of unconsolidated rock, screened off by washing through a fine sieve, is approximately in direct proportion to the sand/shale ratio of that rock. Secondly, it is assumed that an uninterrupted series of screen samples collected at close intervals in a drilling well should reflect all changes in the formational properties of the bore hole.

Both assumptions are disputable. Consequently until now it had been taken for granted that diagrams based on cutting material, of which the components were not properly separated and determined, must be worthless. However, with the object of making use of the valuable data provided by the continuous stream of cuttings, that are too often washed away unexamined, experiments were carried out to see how far a simple and fast method could be developed to save at least part of the information otherwise lost.

Procedure

1. **Preparation of Residues:** At every 5 or 10 feet cuttings should be collected from the previously cleaned shale shaker. From each sample (soft when freshly taken) 100 cu. cm material is separated. This amount is washed under the tap through a set of three sieves (40-, 100- and 200-mesh) in the same way as is done in a paleontological laboratory.

   The washing is finished when the residues left on the three sieves are free of clay or soft shale particles. The three residues are dried quickly in an oven and their volumes measured separately by means of a graduated glass.
2. **Plotting:** The percentages of material left on the three sieves, obtained from each cutting sample, are plotted horizontally one after the other on a diagram, and the

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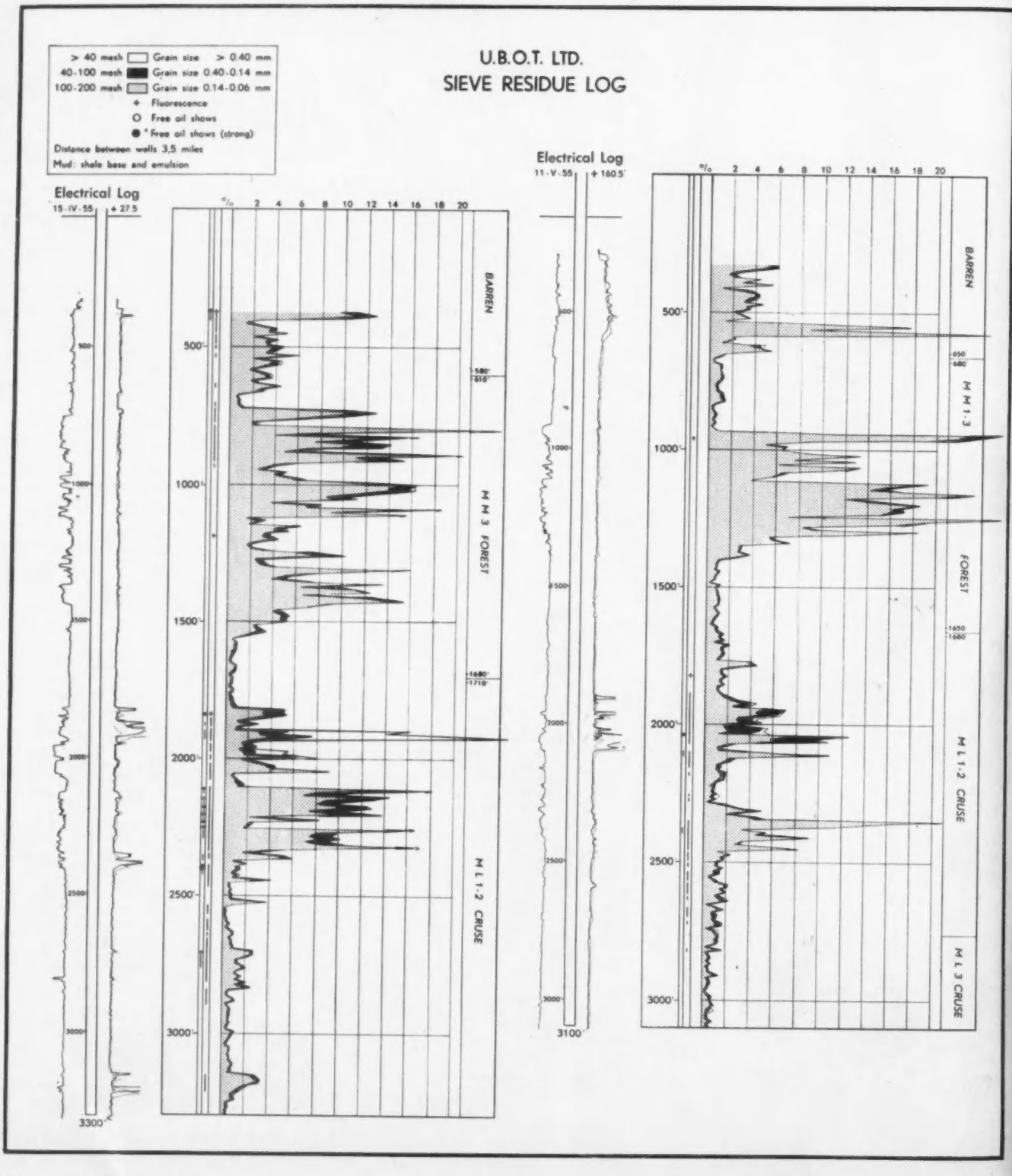
total percentage of residue obtained can be read at the top of the diagram. The scale, though arbitrary, should be chosen carefully to make the graph comparable with the electrical log. The horizontal scale used here is half a centimeter for one percent of material on a vertical scale of 1:2,500 feet (see text figures).

From the legend it can be seen that the amount of fine residue is plotted first and that the percentages of medium and coarse material are recorded additionally towards the right. In practice the three connecting lines are drawn on the working sheet with colored pencils. Finally, the three spaces corresponding with the three fractions of residue are colored in red, blue and green respectively.

Advantages and Limitations. Principal advantages of the method are that it is fast, inexpensive and simple. Furthermore the S.R. log can be drawn to a scale directly comparable with an electrical log curve. With cuttings of good quality, the log gives a sufficiently reliable picture of the clay and sand intervals in the bore hole without interfering with the drilling operations. This ready-to-hand

Continued on Page 214

Comparison of S.R. and electrical logs.



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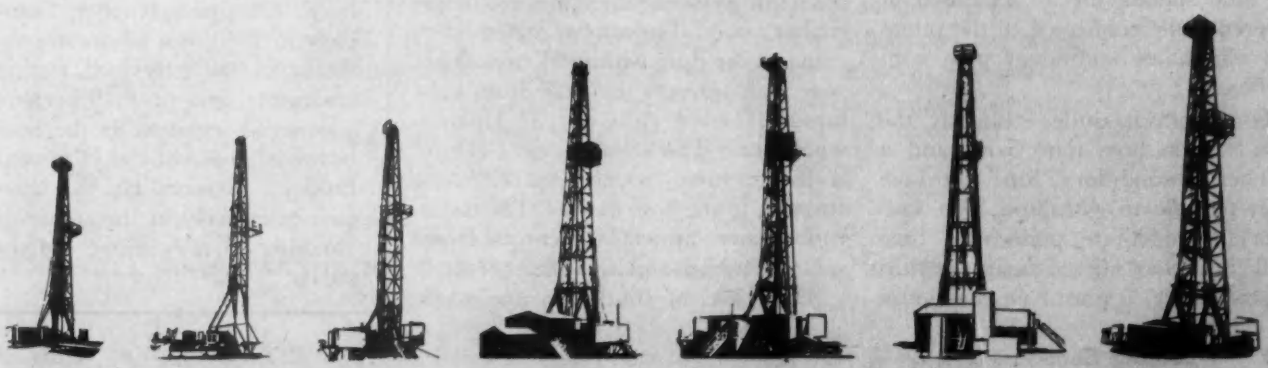

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There's more to this stubby length of hose than meets the eye. It's mud pump suction hose—a vital link in the production of oil. It's tough all over with a tube that could outwear steel. Heavy spring steel wire, spiral-wrapped and imbedded in rubber, prevents hose collapse under the highest vacuum pressures used in mud pump work.

Courtesy of the B. F. Goodrich Company, Industrial Products Division, Akron, Ohio

How to Get the Most From Mud Pump Hose

The short stubby length of hose that provides flexibility to the mud suction is an important cog in the rig machinery . . . Take Care of It.

By RICHARD C. STONER
B. F. Goodrich Company, Akron, Ohio

ONE OF THE KEY parts in the mud flow system of a drilling rig is the mud pump suction hose. This hose is used to convey the mud and make the flexible connection between the mud pump and the slush pit, but the importance of its role in the operation of a drilling rig often is sadly neglected. In addition to doing the job of an equal length of steel pipe, this hose absorbs pump vibrations, allows the mud suction line to be raised or lowered while connected to the pump and eliminates additional pipe connections.

To perform its duties efficiently, the mud suction hose must withstand a number of conditions. First, the hose must be able to withstand high vacuum for indefinite periods of time while in various curved positions without collapsing. It must have maximum flexibility so that it can be curved as required without kinking or causing excessive stresses to be set up in the hose wall. The inner liner must be capable of resisting the physical and chemical properties of the mud. The cover must be able to withstand the abrasion and rough treatment it gets in service plus effects of climate.

The carcass of any mud suction hose is made up of four main elements: the rubber inner liner, the wire coil, the reinforcement fabric, and the outer rubber cover. The rubber inner liner contains the fluid within the hose. The wire coil prevents the hose from collapsing under vacuum or kinking when bent. The reinforcement fabric is the member which contributes strength to the hose carcass. The outer rubber cover protects the carcass from wear, abrasion and weather.

There are, of course, various ways

About the Author

RICHARD C. STONER graduated from Akron University in 1939 with a B. S. degree in mechanical engineering. He joined B. F. Goodrich Rubber Company in 1948 as a laboratory assistant in the physical testing laboratory, and in 1949 became a materials engineer in the hose technical group of the Industrial Products division. He has traveled extensively in the oil fields handling rotary hose assignments.

talk of the industry...

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of combining these elements in the manufacture of mud suction hose. There are also various types of rubber, wire and reinforcement fabric. The best mud suction hose, therefore, must be made up of the right combination of the most suitable elements.

It has taken many years of experiment to determine the most suitable elements and the most effective combination of these elements. Materials are being improved all the time and hose manufacturers constantly are scrutinizing their products to determine how these improved materials can best be utilized.

The most recent development in design of mud suction hose is the use of cord reinforcement. This cord replaces the square woven fabric formerly used. Mud suction hose of this design currently is being marketed.

Cord reinforcement has cords running in one direction only. Square woven fabric has cords running in two directions. The cord reinforcement has a number of advantages over square woven fabric. The cords can be applied at the optimum angle, the "crimp" or "take-up," which is the decrease in length resulting from weaving square woven fabric, is eliminated; and each cord is completely imbedded in rubber. These three factors combine to make the hose lighter, more flexible and more resistant to outside abuse.

Mud suction hose, however, is no different from any other piece of equipment on the drilling rig in that in order to obtain maximum service, it must be handled and maintained properly. Cover gouges should be repaired with air curing dough. If the cover should show tendencies to crack, it should be painted with weather resistant paint. It is important to keep the outer cover in good condition, as most fabrics will deteriorate rapidly when exposed to the weather. The steel wire will corrode when exposed to moisture.

Care should be exercised, particularly, when changing location. The hose should not be dragged any more than absolutely necessary and should be handled in such a manner that it will not be crushed out of round. The hose is designed to take even abnormal abuse but it is not indestructible.

The mud suction hose is a vital link in the mud flow system which is the life blood of a drilling rig. Without it, drilling stops. —**The End**

Sieve Residue Logs

Continued from Page 208

subsurface information may save footage or unnecessary electrical logging in tectonically disturbed areas.

Also the S.R. log appears to be the nearest substitute for an electrical log (see under "Oil Shows") when technical difficulties prevent running of the latter. Finally, it facilitates the interpretation of Neutron and Gamma Ray logs, when resistivity and potential logging is precluded on account of the use, for instance, of oil base mud. In fact it has been found that the results of S.R. logging are even better in wells drilled with oil base mud.

But there are limitations. Most important is that the method can only be applied on fairly soft rock cuttings. Also, some knowledge of rock components is necessary. High peaks on the log may be caused occasionally by floods of foraminifera, concretions of pyrite or siderite, glauconite, coal, cement etc. Before definite conclusions are drawn from the sieve residue log, intervals in which the screen samples may be badly affected by slow rate of penetration, decreased mud circulation, caving etc. should be ascertained from the drilling engineer or from the drilling reports.

With normal progress and constant circulation it has been found that the cuttings collected are in general sufficiently representative for the formation penetrated. Satisfactory logs have been produced from wells as deep as 9000 feet.

Depth lag is considered another drawback of cuttings evaluation. Consequently the value of a S.R. log is decreased. In practice it was found that the time lost by computing the (usually minor) corrections was not worth the trouble. Later comparison of the uncorrected S.R. log with the electric curve has the advantage that samples, specially collected for laboratory examination, can easily be shifted to their proper position.

It will be understood that an S.R. log cannot yield real sand percentage of the rocks penetrated as a large part of the loose quartz grains from the cuttings are lost during transport to the surface and are washed away through the shale shaker. Nevertheless, the log often reflects with a surprising accuracy the alternations of sand and shale intervals and provides petrological information welcome under certain circumstances.

Residue Log and Electrical Log. Generally, when drilling through pure shales, neither of the two types of log will show any indications. Both will register pronounced peaks on passing a sand interval.

It has been noted that the presence of certain minerals, including sparse quartz grains, fossils or concretions in the shales, has only little if any influence on the electrical curve. These minerals may show up on the S.R. log.

It is obvious that such peaks, although sometimes of correlative value, are of no practical significance for the petroleum engineer. To prevent misinterpretation it was found advisable to check regularly with a magnifying glass the composition of the residues causing high peaks on the residue log.

Conclusions. Due to dispersion of part of the soft cuttings in the mud stream, only a small percentage of the real sand content of unconsolidated sand layers is recovered from screen sample material. In general however, the S.R. log is found to follow closely the changes from sand into shale, or the reverse.

It is also felt that the speed and simplicity of the method compensates for the uncertainty resulting from the somewhat variable quality of the cuttings on which it is based. An S.R. log, preferably in conjunction with a drilling time log, may serve as the nearest substitute for electrical diagrams in case of failure to procure the latter.

Oil-Shows. A commendable refinement is the plotting on the S.R. log of the presence and intensity of fluorescence observed on the freshly taken screen samples. Another method is to leave the samples (recovered from water-base mud) soaking for a while in water. Oil, if present, will be seen floating at the surface after a few hours. It should be borne in mind that the oil/water ratio of the rocks cannot be estimated by this method. In spite of distinct oil-shows some sands may be found uneconomic.

Nevertheless, the early knowledge that certain sand intervals are almost sure to be wet or oil bearing, is not only of general interest but may prove of real importance under circumstances where an electrical log has not yet been or cannot be made.

ACKNOWLEDGMENT

The author thanks the United British Oilfields of Trinidad, Limited for their permission to publish this article.

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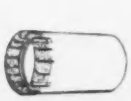

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By W. M. AULT
Delta Gulf Drilling Company

A SAFETY PROGRAM can be based on the belief that there are but two factors involved in practically all accidents:

- Men
- Equipment

Since man, for the most part, controls and operates the machines and handles the materials, most of the responsibility for eliminating accidents rests with him.

Recognizing man's responsibility in its accident prevention program, Delta Gulf Drilling Company's efforts are primarily directed towards (a) personnel improvement so that men understand the tasks to be undertaken and how to perform them well and with safety; (b) adequate training; (c) physical fitness. The basic points of the safety program are recognized throughout the organization and apply to all personnel, whether in management or in the field.

Selection of Men. Drillers hire most of their crews. The safety program stresses the importance of hiring men who are of legal age, mentally mature, and if possible experienced. Drillers are urged to be careful in their selection, and where possible to hire married men who are responsible and settled, with moderate habits, and who possess good background with evidence of adaptability. All applicants for jobs are required to pass a pre-employment physical examination.

Shortly after a new man is hired the tool pusher explains the company's safety program, policies, benefits, etc. The importance of safety is emphasized and the men are urged to participate in the safety program. The new man is given to understand that,

Continued on Page 237

What Are Safety Problems Of a Drilling Contractor?

Selection, training, teamwork, standardization, and good communications all lead to the development of a profitable safety program.

By C. A. NABORS
Parker Drilling Company of Canada, Calgary

THE SERIOUSNESS and frequency rate of accidents on a rig is closely connected, usually paralleling, the efficiency of operations and the profits derived. In this connection personnel problems are the most important.

Many of the personnel problems can be reduced or eliminated by careful screening, and hiring only those men who have the characteristics and abilities to perform the job in the manner desired, and who will likely continue in the employ of the company after they have become experienced.

Very few crewmen are hired through a head office or a field office. In a majority of cases, a driller does the hiring and he does not have time to check and interview his men.

A few of the drilling contractors in Western Canada are attempting some type of screening method. One method being used is where the field office personnel interview prospective employees and set up a file on each of them, showing their working experience and as much about their character as can be learned. Whenever a driller or toolpusher requests a man, an attempt is made to send him the right type. Another method that is being tried is where the driller finds himself shorthanded and picks up a man with the understanding that he will have eight hours of work but during the eight hours or immediately after, the driller will have him interviewed by the toolpusher who will decide whether or not this man has the necessary qualifications and is the type of man that will fit into the crew. If the toolpusher feels that the man is satisfactory, a report of his findings is turned into his office, together with the man's unemployment insurance book and the man continues on the job. If not, the driller is told to give the man a time order for the one day and to look for another man.

Both these methods are meeting with some success and the time is not far distant when most drilling contractors will be using some screening method to employ men. Men properly suited to their jobs add to efficiency and improve the accident rate.

Training. Training of new men needs analyzing and improving. The absorbing of one new, green man into a crew of otherwise experienced hands is the best way to break a man in around a rig. That is, provided the other crew members have the proper attitude and are willing to instruct him properly. A driller allowing a new man to perform a function incorrectly is telling that new man that the wrong way is the right way. It is not enough to simply tell a man the right and the wrong way but to show him why the correct way is the best way and what may result if the wrong way is used.

The toolpusher is the key man in carrying out any training and safety program on his rig. His attitude towards the program will be immediately reflected in the attitude of his drillers. A toolpusher sincerely believing in a program for his rig can make such a program successful. His attitude that the program is not essential will surely slow it and perhaps defeat it.

Training of new personnel on the rig to fit into a drilling crew can get off to a good start if the toolpusher will take each new man and explain carefully the company policies, safety regulations about the rig and, generally, what the company expects of the new employee. His interest in the new man will greatly aid that man to adjust to the company and to work required.

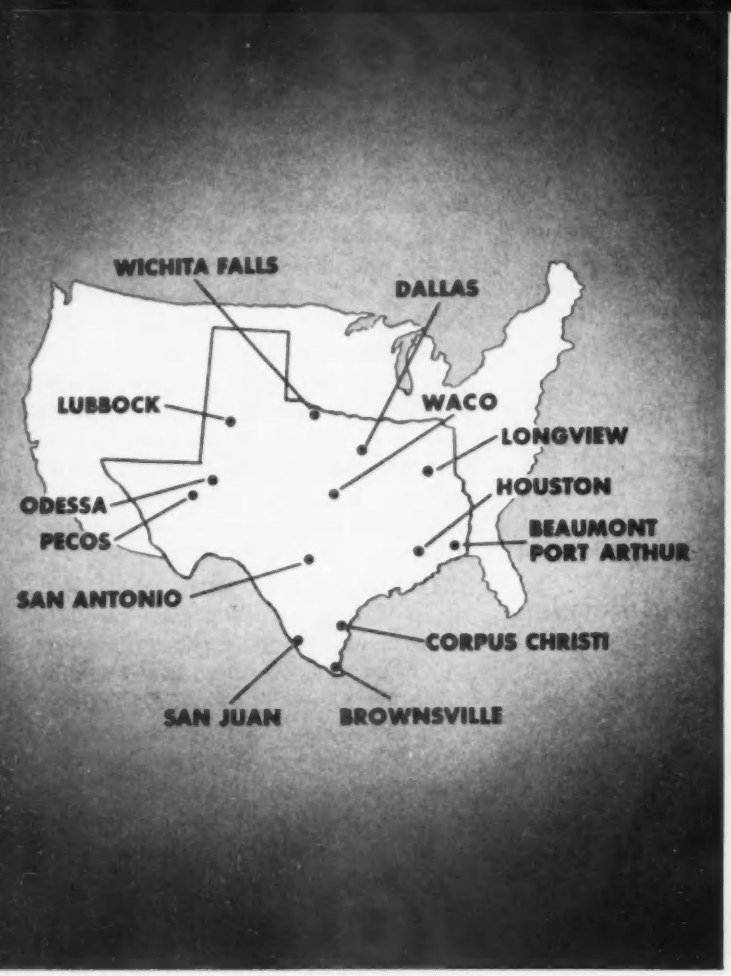
Instill, as early as possible, in the mind of the new crewman a pride in his job and desire to work efficiently and safely. A company whose management, president to drillers, is working as a team to do the best, most efficient and safe drilling job in the industry, cannot help but impress the new man, and create in him the desire to be a part of the team.

Training must be a continual process. Introductory training in the rudiments of handling the floorman's job is only the beginning. Power drilling rigs, with their multitude of accessories, are exceedingly complex. Training to use and care for the items of equipment on the rig is never-ending.

There are real safety problems in properly schooling rig personnel to care for and to operate equipment properly. Thorough understanding of the function of each unit of equipment is primary. Knowledge of the limitations of the items of equipment on a rig is also mandatory to operate it safely.

Procedures of drilling operations, testing and coring, deeper wells and new completion methods increase the need for training and study on the part of the entire team. Today the need exists for intense training of personnel. Greater emphasis within the company organization on introductory training and continuous training

Continued on Page 242



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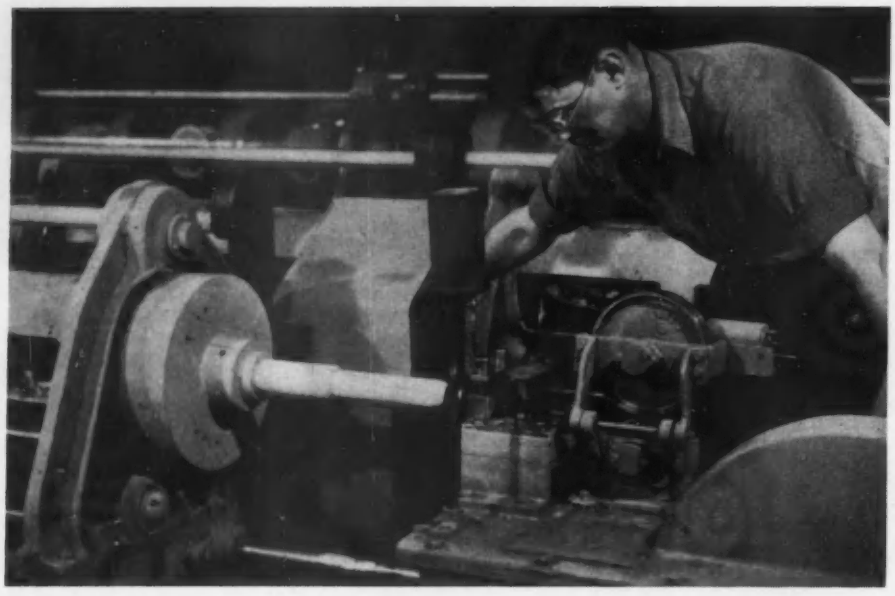

MAKING A TAPER. Six strands, spooled on bobbins, are loaded in this closing machine.

What's Wrong With Tapered Drilling Lines?

Here are the big reasons why they are used and some of the limitations.

By L. C. TORELL
Bethlehem Steel Company
Bethlehem, Pa.

AN OVERWHELMING majority of the oil and gas wells in the eastern oil fields of the U. S. have been drilled with percussion tools for the practical reason that the cost per foot of hole has been substantially less than in the case of wells drilled with rotary tools. The shattered, tilted, and often porous formations of the Appalachian geological strata have made rotary drilling generally more costly.

No unusual problems were encountered in cable tool or spudder drilling until the search for deeper and deeper production resulted in wells considerably beyond the 6000-foot depth, with some even going beyond 10,000 feet. The weight of the freely suspended drilling line, plus the weight of the tools, becomes critical in relation to the breaking strength of the line at about 6000 feet.

Analysis of Safety Factor. Let us examine a 1-inch diameter 6 x 21 filler-wire, mild-plow, fibercore drilling line at the 6000-foot level. The weight per foot is 1.60 pounds and the minimum breaking strength is 63,200 pounds. The suspended line alone weighs 9600 pounds, the tool perhaps another 4000 pounds, making a total static load of 13,600 pounds. This is about 21.5 percent of the breaking strength. This is not much of a safety factor for the highly fatiguing, harmonic action of percussion drilling when static loading alone is considered. The actual load is considerably greater because of such factors as water in the hole, crooked hole, etc.

The obvious first thought is to use a larger line. Experience has shown this to be impracticable. However, to demonstrate a point, a 1⅛-inch diameter line of the same construction and grade weights 2.03 pounds per foot and has a breaking strength of 79,600 pounds. The suspended 6,000-foot line weighs 12,180 pounds plus the tools at 4000 pounds, a total of 16,180 pounds, or 20.3 percent of the breaking strength. Thus the larger rope offers no appreciable gain in safety factor.

A similar analysis for a 7500-foot depth gives results shown in Table 1.

At 9000 feet the three sizes figure are as shown in Table 2.

TABLE 1

Diameter, Inches	Lbs., per Foot	Minimum Breaking Strength Lbs.	Total Static Weight Line Plus Tool, Lbs.	Percent of Breaking Strength
⅞	1.23	48,600	13,225	27.2
1	1.60	63,200	16,000	25.3
1⅛	2.03	79,600	19,225	24.2

TABLE 2

Diam., Inches	Total Weight Line Plus Tool	Percent of Breaking Strength
⅞	15,070	31.0
1	18,400	29.1
1⅛	22,270	28.0

In both tables the weight of line plus tools includes dead load only. The actual operating loads are indeterminate and appreciably greater.

Evolution of Tapered Line. Such loadings are obviously excessive and percussion drilling at these depths is consequently impracticable with wire rope of uniform diameter. This has resulted in the evolution of the so-called tapered drilling lines. Theoretically, the ideal line for the purpose would be one having enough strength and diameter at the bottom end to carry the tools with an adequate safety factor. This line should taper uniformly upward in diameter and strength to compensate for the added weight of the suspended line. Practically this is not possible because of

About the Author

L. C. TORELL was born in Cambridge, Minn., served in the Navy in World War 1, and studied civil engineering at the University of Minnesota. In 1923 he was employed as field engineer with Toltz, King & Day, St. Paul, and in 1925 he joined Fegles Construction Company of Minneapolis. Here he supervised the construction of grain elevators, locks, dams and similar projects. In 1936 he went with Williamsport Wire Rope Company and when this company was acquired by the Bethlehem Steel Company in 1937 he remained with them as wire rope engineer.

manufacturing limitations.

The earliest effort to solve this problem was a simple one. It consisted of field splicing 7/8-inch and 1-inch lines into one line. Tucking 7/8-inch strands into 1-inch rope and 1-inch strands into a 7/8-inch rope results in a rough splice which will wear through the outer wires of the higher strands quite rapidly necessitating frequent resplicing. So while deeper holes could be drilled by using such lines the wireline costs were high.

Next came efforts on the part of wire rope manufacturers to make lines approaching the theoretical ideal of a continuous taper. These were never widely used because a uniformly tapered line of uniform quality requires not only uniformly tapered individual wires, and a uniformly tapered core, but also stranding and closing dies which can be irised to match the changing sizes of, first the strands, then the rope, and still maintain proper pressures. There simply is no equipment available for doing such a job.

Development of Stepped Lines. The practical solution was found in today's so-called tapered lines. In reality these are stepped lines consisting of two, sometimes three, and even four progressively smaller sctions of like construction and diameter tapered one into the other. The length of each taper is usually not less than 2400 times the diameter of the larger rope, or, 200 feet for a 1-inch to 7/8-inch taper. Tapers are commonly specified in 1/8-inch diameter increments. Some users feel that the rather high extra cost of more frequent tapers in 1/16-inch increments is justified.

The actual tapering starts with the electric butt-welding of one of the main wires of the larger strand to a main wire of the adjoining smaller strand. Similar welds are made in each of the main wires at appropriate intervals. The 200 feet is divided into the proper number of equal spaces. The filler wires are likewise joined, with all welds in both main and filler wires approximately equally spaced. Since a main wire in a 1-inch 6x21 filler-wire drilling line is only about 0.009 inch larger than that of a 7/8-inch line it is evident that the taper can scarcely be seen with the naked eye. However, it is also obvious that the geometric fit of the wires in the completed strand cannot be perfect within the taper.

Six such strands, spooled on bobbins so that the tapered sections of each will properly match, are loaded into the closing machine. Then the first uniformly sized section of finished rope is closed about the fiber core, in a normal manner, up to the beginning of the first taper.

Then, because fiber cores with matching uniform and tapered sections are unobtainable, the required two sizes of core are hand spliced together with as uniform a tapered section as possible. The unspliced core uniformity and density cannot be maintained in this section. The closing operation is resumed, stops are made at frequent intervals to adjust closing die size and pressure as the diameter changes. This procedure continues until the end of that taper is reached. The normal closing of the next uniformly sized section follows, and so on.

The result is a line with uniformly sized sections having all of the quality and durability of any drilling line. Even the practiced eye can hardly detect the tapers. However, because the wires cannot fit as they should in the strands, and as the core cannot be as perfect as desired, the tapered sections cannot have the full quality and durability of the normal uniform sections. This explains why, despite the theoretical advantages of a continuous taper, the tapers should be of moderate length.

In spite of these inherent limitations, wells have been drilled to depths in excess of 11,000 feet using such lines and percussion tools. But it took a long time to do it.

In use, the large end of a tapered line is of course first on the drum. After the first taper is reached, spooling of the smaller diameter rope is therefore erratic, and cutting through may take place. This condition, and the other limitations previously pointed out, explain why tapered fiber core lines are not very likely to find wide favor despite the theoretical advantages they offer. This is notwithstanding the fact that they have been proposed from time to time.

Even at best, deep well drilling conditions with tapered lines are unpredictably severe. The life of such lines is commonly quite erratic. It is faint praise to say that, regardless of inherent shortcoming, they are necessary in this service.

—The End

Delta's Safety Program

Continued from Page 216

although he is a new employee, any suggestions and views he may have in the interest of safety and of assuring a better program, will carry as much weight as those advanced by the oldest employee. It is impressed on the new man that during safety sessions it is his duty to bring up for discussion any ideas or suggestions which will improve the company's safety efforts. Safety meetings are held once a week and all crew members and others connected with the rig operation are required to be present.

Weekly Safety Meetings. Delta's ever-improving safety record is believed by management and the Safety department to be attributable directly to the weekly safety meetings. The meetings are short, generally not more than 15 minutes. They are carried out in an atmosphere of informality. The men realize that safety affects them and their families as well as their earning power. Therefore these weekly safety meetings are carried out with interest and earnestness. A written report of each meeting is prepared by a member of the drilling crew, usually the driller. One copy is submitted to management and another is retained at the rig. The chairmanship of the weekly safety meeting is rotated among the driller and crew members. Reports must bear the signature of the chairman, driller and tool pusher.

It is the rule at the weekly safety meeting to take up only one subject and discuss it thoroughly. Each crew member is encouraged to express himself freely on procedure and methods. Following these discussions it is noticed the men not only get a "new look" at the job, but they leave the meeting with a much better understanding of the job and how to make it safer.

Subjects selected for discussion deal with rig equipment and its operation; rigging up and tearing down; and functions of the drilling rig. Tool pushers attend meetings at irregular intervals and the meetings do not depend on their being present. Usually, men talk more freely when the "boss" is not around.

Rig Inspections. Each Delta crew makes one monthly inspection of the rig. Crew members rotate this re-

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sponsibility. The Standard AAODC Rotary Rig Inspection Check Sheet is used. These inspection reports are made in duplicate, one is retained at the rig, and the other two are forwarded to the division office. Based on the monthly reports and recommendations of the driller and safety supervisor needed physical rig repairs are made. The purpose of rig inspections is to make crew members conscious of their responsibilities in handling and working with machinery and equipment. It is designed to impress upon the men that they are responsible for maintenance. Also it helps to familiarize them with their rigs, and impresses upon them the fact that a well-maintained rig or piece of equipment contributes to their own safety and efficient operation of the rig. Delta feels that crews who make their own inspections, report needed repairs, discuss maintenance problems with drillers and tool pushers, will develop a keener sense of responsibility and pride in their job and the tools with which they work.

Safety meetings and periodic rig inspections are considered by Delta as invaluable "safety tools." Without them, or something along the same lines, a Safety Program cannot be successfully followed through. Records are of the utmost importance so that management, the safety supervisor, and the men themselves, will understand how the program is working.

Another important tool in the "safety kit" is the practice of having the men actually make out an accident report. It is felt that a crew man making an accident report is more deeply impressed and becomes more conscious of the need and functions of a safety program. Following an accident, the first report of injury is presented to crew members who were at the scene of the accident. They are requested to make a clear and brief statement as to how the accident occurred. The report is signed, not only by the man or men who witnessed the mishap but by those who did not. The latter state on the report that they did not see the accident happen.

The practice of reporting upon an accident without undue delay has proved of considerable value in Delta's safety program. In this way the records contain statements of the circumstances surrounding the accident while details are still fresh in the minds of those who witnessed the mishap. Drillers are required to note on their Daily Drilling Report whether or not accidents, no matter how minor, occurred during their tour. If no accident took place he notes, immediately above his name: *No accidents on this tour.*

Management Participation. In order for a Safety Program to be effective and "stay alive," it is necessary that all echelons in a company take an interest, and wherever possible, particpate in the program.

Delta managers meet with tool pushers and exchange suggestions. They discuss policies, problems, and other matters affecting safety which, in their opinion, will improve the program. They visit rigs and commend crews on their accomplishments. They inspect safety gear and supply whatever is lacking. The company furnishes special protective equipment such as goggles, rubber gloves, etc. These periodic visits are appreciated by the men.

As in all safety programs, the safety director must play an effective part if the program is to succeed. At Delta the safety director is responsible for the study of the latest safety methods. He is called upon to furnish constructive thinking and ideas and to meet regularly with the men. He must make periodic visits to all rigs. Every two months he sends an "open letter" to the tool pushers which deals directly with the safety program and personnel problems.

Toolpushers Responsibility. Safety is a "two-way" street and toolpushers, drillers, and crew members are expected to actively participate in all safety endeavors. A heavy responsibility rests particularly on the tool pusher. He is accountable not only to management, but to the men who work under his direction. Every toolpusher should be extremely safety conscious and at Delta this attitude is expected of all toolpushers. A "safety conscious" toolpusher invariably has a low accident record at his rigs.

All crew members must be safety conscious if they are to work safely and make a company-wide safety program successful. In some organizations responsibility for safe operations are delegated to the Safety Director alone, while management is inclined to shirk its responsibility in this field. This policy cannot be successful. In

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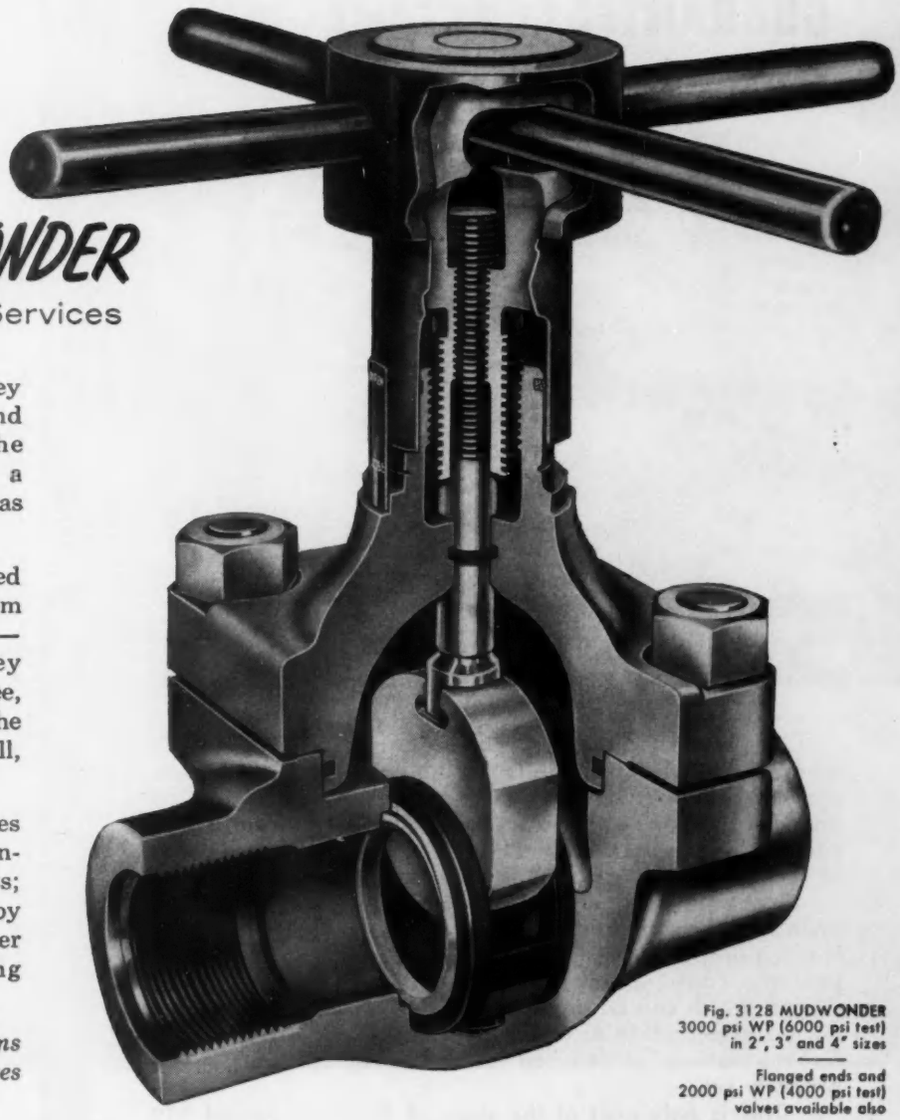

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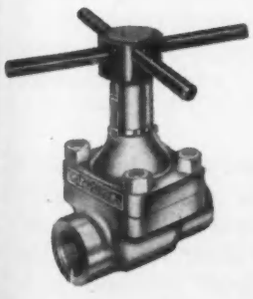

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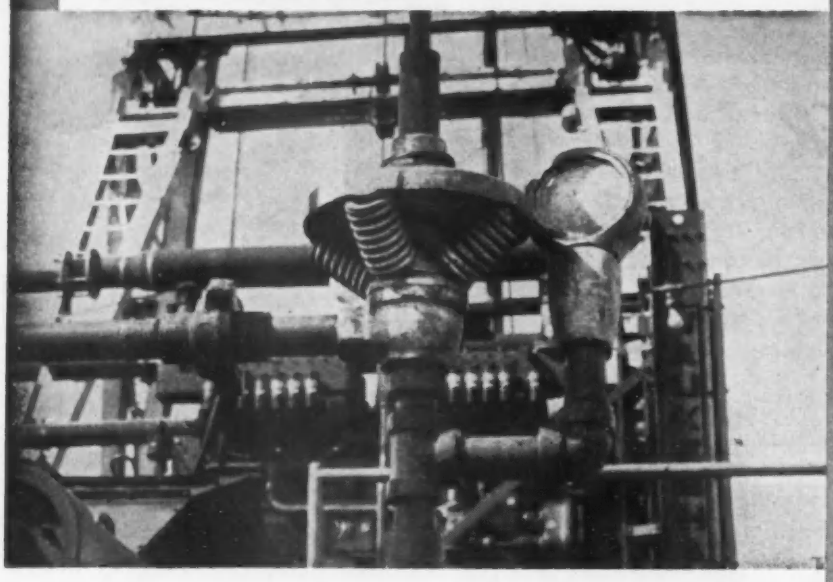

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safety work equal responsibility must be shared by all. A study of accident records around drilling rigs proves beyond question that accident prevention is everybody's business. If management is not willing to actively support a safety program, and the men in the field are not interested in a good safety record, and all are not willing to work to achieve such a record, then it is inevitable that men will get killed or hurt around the job.

To develop a good safety program and achieve a good safety record, safety must be a part of the job—not apart from the job. The rules of safety must be fair and impartial and must be gently and firmly observed.

At Delta, safety is uppermost in the minds of all employes. This policy has met with considerable success. It is based on three fundamental rules: careful selection of personnel; thorough training in safety for all; a determination on the part of crew men to make their individual operation the safest in the entire organization.

—The End

Analyzing Safety Problems

Continued from Page 229

for all crew members in the proper care and handling of equipment will pay dividends in higher efficiency and improved accident experience.

Teamwork. Within an organization teamwork can do great things to provide a more injury-free place to work, provide higher efficiency in whatever the team undertakes and make for greater satisfaction and happiness from the job completed. Teamwork is made up of many intangibles, as well as such things as having fine equipment to work with, good working conditions and good wages. It requires the work of the entire organization to handle all the sequences of events, from the preparation of the bid to drilling the well, down to the preparation of the invoice to the oil company for the completed well on production. Top management should provide the incentive and the desire for all to work as a team. Teamwork pays off.

Labor Turn-over. It has been found that generally the accident frequency rate of a contractor will directly parallel the rate of labor turnover. The higher the turnover the more acci-

Wire Rope at Work—This crew struck oil in the Gladys Pool, Sedgwick County, Kansas, and here you see them about to run a drill-stem test. The well had reached 3195 ft; at that point it was in Mississippi dolomite. The Laura Jane Oil Company, owned by D. M. Shawver, drilled the hole and planned to produce and sell the crude.

One of the hardest-working components of the drilling rig was a Bethlehem Purple Strand rotary line. A Form-Set (preformed) rope, it had seen active duty on a number of previous jobs. This was its twelfth, with others to come; for the rope was in excellent shape, and gave promise of living to a ripe old age.

Bethlehem Steel Company, Bethlehem, Pa. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Mill depots and distributors from coast to coast stock Bethlehem rope for the following industries and numerous others:

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dents. Pre-employment screening, group hospital and life insurance plans, better management and the providing of housing in remote and congested areas has helped. Much more thought and work are required to further reduce the loss of experienced men and to attract the type of man the industry needs.

Communication. Good communication between all members of the management team which includes all persons supervising the work of others, is necessary to fully utilize the abilities of all. Communication must be two-way. Top management must be able to reach the ear of the crewman to encourage him to want to work in a diligent and safe manner. Conversely, the crewman and driller should be able to communicate to the top man any constructive ideas they may have to improve methods, cut expenses or decrease hazards. Personal communication between top management and rig personnel has been limited frequently by the great distances between home office and remote wells. Company owned aircraft has been a great aid to some companies in enabling supervisory personnel to visit all rigs when desirable.

Standardization. Little has been done to standardize blowout prevention equipment and hookups. Standardization and simplification of blowout preventer controls can do much to enable any crewman, if he has been properly trained, to actuate the proper preventer at the proper time in the event of an emergency.

Well Completion Methods. Well completion methods have become more complex and more of a safety problem due to high pressure sometimes employed. Due to the various producing formations, their characteristics and their depths, it is difficult to standardize procedures. Therefore, there is need for closer supervision by the oil company and the contractor than ever before. Good understanding between the contractors men, company engineers and service companies adds greatly to efficiency and accident-free operations.

Customer and Public Relations. A good record of drilling wells in an efficient, economical and safe manner is the best sales factor the drilling contractor can have. All oil companies are seriously concerned with public relations. Many of them market their products to the public through service stations. All realize that good public opinion is mandatory to continued success.

The drilling contractor in effect, represents the oil company in the locality where he works. His ability to work safely, to earn a good reputation for handling personnel and business reflects favorably on the oil company. High accident rates, high labor turnover and neglect in other ways gives the customer a black eye.

Improvement of accident experience in the contracting industry during the past few years has contributed to earning a good reputation for the contractor, but long-range plans are needed. Implementation of those plans with energy and drive will enable the contractor to better discharge his duties to the petroleum industry and to provide a safe and more profitable future for his personnel and the companies for which he works.

ACKNOWLEDGMENT

This article is based on a talk presented at the fourth annual Drilling Safety Clinic, Banff, Canada, sponsored by the Canadian Association of Oilwell Drilling Contractors.

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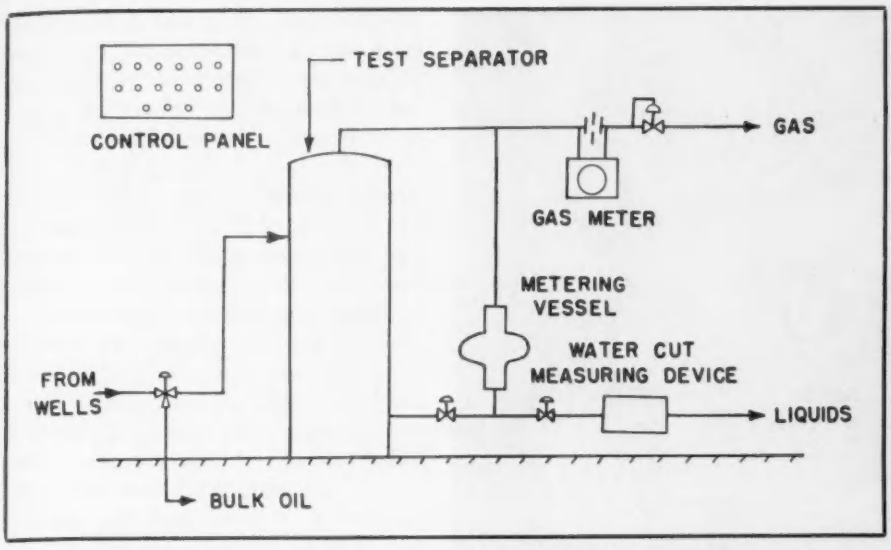

FIGURE 1—Automatic well-test systems such as this one have received a great deal of attention and some very satisfactory results have been achieved.

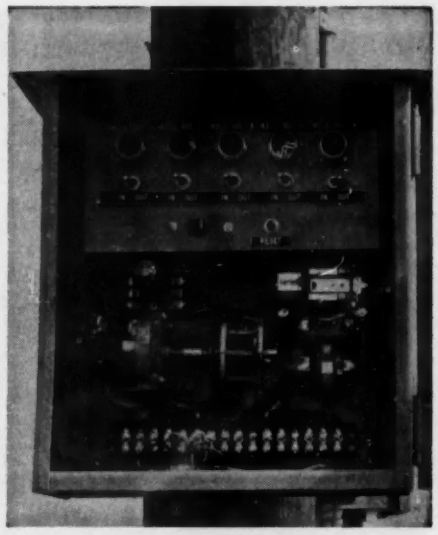

FIGURE 2—Many new systems are installing automatic tank switchers such as this one.

What About Automatic Production Controls?

• Though still in the development stage, they have a place in lease operation.

• Here is where they are being used and some of the problems that remain to be solved.

By L. M. HUBBY
The Texas Company, Houston

AUTOMATIC PRODUCTION controls have come a long way in recent years but many problems remain to be solved. Some of the rosy predictions made for things to come in this field may never be realized because of practical considerations.

However, within limits of economic and operational feasibility, automatic devices still have a place in lease operation.

The application of automatic devices to lease operation may be said to be in a developmental stage at present. Some applications are well established and are no longer regarded as "automatic controls," inasmuch as this classification is commonly thought of as meaning something new and different. Other applications are still in the test-tube stage. Problems vary from that of basic acceptance of the idea of automation in some areas to that of availability of equipment in other areas.

The majority of automatic-control installations to date in lease operations have been installed as modifications of existing systems. The best applications are usually in new facilities where the cost of removing existing installations is eliminated and where adjustments in the work force are reduced to a minimum. However, methods and equipment must be standardized before new installations can be undertaken on a routine basis.

By "standardized" as used here, it is meant that in addition to having a workable and satisfactory system available, the field men must be sufficiently familiar with the system to plan its incorporation into the new installation, to operate it efficiently and to maintain it after installation. It also means that the necessary equipment must be available on short notice and service obtainable when required.

In most areas, these requirements have not yet been met. Before they can be met, methods must be standardized so that custom-built costs are eliminated, delays in fabricating are reduced, and items can be stocked for quick delivery.

Much of the work which has been done so far toward automation of well testing, tank switching, and custody transfer has been in the nature of developmental work and eventually will provide a basis upon which standardization can be reached. A number of interesting and important developments have come about in this way, and some problems for which there is no economical solution at present have been recognized. Among these, the following items are worthy of note.

Control of Wells. In the control of stripper wells or other small producers having low bottom-hole pressures, the "pump-off detector" appears to fill a definite need. This device determines

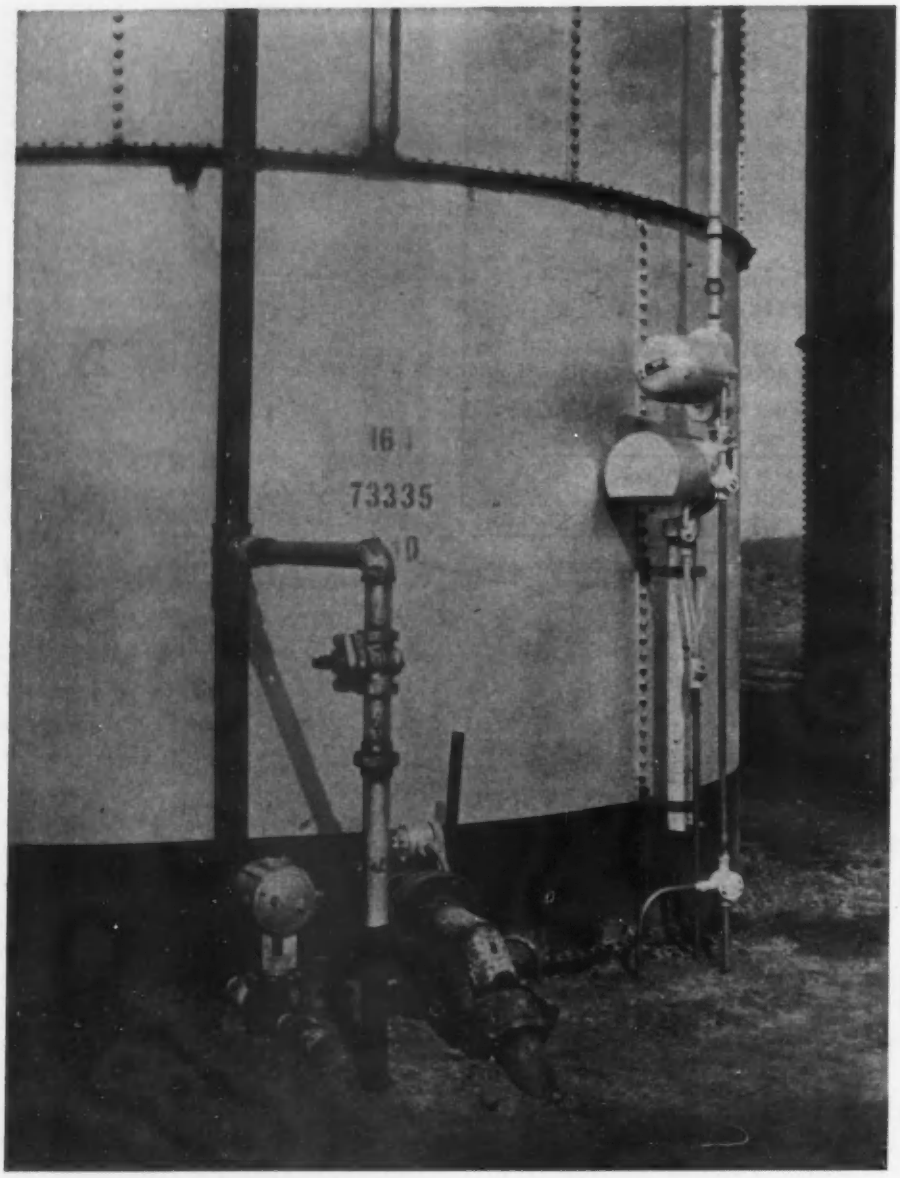

FIGURE 3—Tank units of electric tank switching and remote tank-gaging installation.

when the well has pumped off and stops the pump machinery. At present, the use of this device is limited to electrified wells which can be automatically restarted after each off period. Worthwhile savings in power costs and equipment wear can be effected when this device is properly applied.

Measurement of Crude Oil. Metering vessels represent one of the important developments in the measurement of crude oil. These devices overcome most of the limitations of positive displacement meters where gassy crudes are to be measured or where slugs or gas may be present. They are being used in well testing, in measurements for royalty payment before commingling at consolidated batteries, and in similar applications.

They have established satisfactory records of operation in practically all instances and their use is spreading. First cost is greater than for positive displacement meters but the payout comes through better accuracy and lower maintenance costs.

Well Testing. Automatic well testing has received a great deal of attention and some very satisfactory systems have been developed. A typical system is shown diagramatically in Figure 1. The control panels used for switching wells and recording results are now available with hermetically sealed components and with results recorded, either as chart data or as printed figures, showing well number, date, production figures, and duration of test. Other components of well-test systems, such as manifold valves, gas-metering systems, and water-cut measuring devices, will require further development before a really economical well-test system can be built.

The most economical applications for automatic devices are those in which the device operates at frequent intervals, hence eliminates a great deal of manual attention, e.g., a separator dump valve or a well intermitter. Probably the most uneconomical part of present well-test systems is the manifold valves which are required to operate only once during a well test and which then remain idle for as much as 10 to 30 days.

As a further example of the need for development, present gas-metering systems are unable to handle the wide range of gas flows which are encountered in well testing unless a very elaborate system is used. In testing wells, it is not uncommon that the maximum gas-flow rate measured at the battery from the largest gas producer is 100 times the minimum rate from the smallest well, whereas the usual orifice meter has an accurate range of only about 3 to 1.

Systems involving as many as four meter runs have been used to obtain the necessary range. Variable area meters, in which the differential pressure is held constant by varying the size of the orifice, can cover a 10:1 range, which is still far short of the requirement. A definite need exists in this regard and will no doubt eventually be met by equipment manufacturers.

Payouts on automatic well testing

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are usually based upon labor savings and upon the improved information obtained from such tests. Better equipment will give better information and a better payout.

The matter of water-cut determination in connection with well testing has been given a great deal of study and several promising arrangements have been worked out for this purpose. Probably the newest of these is the dielectric type which measures the dielectric constant of the fluid and infers the water-cut from this measurement. This instrument offers great promise because of the large difference between the dielectric constant for water and for oil.

However, the instrument has serious limitations at present in well-test service because it is adversely affected by free water, by variations in the size of the droplets in an emulsion, and to a lesser degree by gas, paraffin depositions, and the rate of flow through the measuring element. When these factors are properly controlled, fairly accurate results can be obtained.

Samplers have long been used for water-cut determination but have always been seriously limited in well-test service by the non-homogeneous nature of the fluids being sampled. Recent developments in this field include improved sampling tubes to obtain a more representative cross section of the fluid and an increased sampling rate to provide a statistically better sample, on the theory that if enough samples are taken per unit volume, a representative sample can be obtained on the most non-homogeneous fluid. In practice, sampling rates as high as 20 samples per barrel have been tried and results indicate that a more representative sample is obtained in this way when non-homogeneous fluids are being sampled.

Heater treaters have been used for water and oil determination in automatic well testing but are expensive in comparison to other methods which measure the water-cut instead of actually separating the water and oil. One of the present needs of the industry is for a less expensive treating system designed for well testing.

Tank Switching. Automatic tank switching has gained wide acceptance and is being installed in new installations in many areas. Three principal types are in use at present: the mechanical routing valve, the electrically powered system, and the pneumatically operated system. A typical electric tank switcher is shown in Figure 2, and its associated tank filling valve, pipeline valve switch, and float switch are shown in Figure 3.

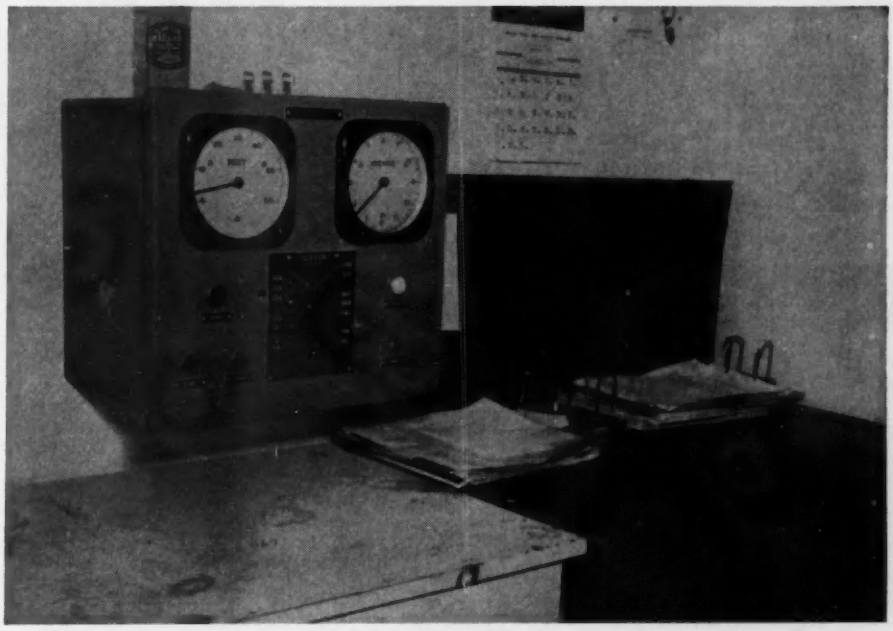


FIGURE 4—This remote gaging panel enables pumper to keep track of 14 tanks in 5 batteries located several miles from gaging point.

Routing valves do not require external power for their operation but have not proved as flexible or as reliable in operation as the electric and pneumatic types. In cold climates, the pneumatic type suffers from freezing unless dry air or gas is used. Bottled dry nitrogen is being used for this purpose in some installations. Electric tank-switching systems in common use are very good, but depend on commercial power for their operation.

Failure of the electric power causes the tank-filling valves to close, so it is necessary to provide some means of stopping or containing the flow of oil from the wells in event of a power failure. To overcome this undesirable characteristic of electrical systems, development work is currently being done on a low-voltage electrical system which derives its power from a thermopile generator which burns lease gas. These generators have no moving parts and require only a small flame for operation. Such a system would be applicable to many tank batteries which do not have commercial power available.

Payouts on automatic tank switching are generally based on labor savings and the better use of tank storage volume. These savings are frequently much better than might be anticipated because the pumper does not have to be at the battery at a particular time to switch tanks, hence can schedule and perform his work more efficiently.

Remote Tank Gaging. Remote tank gaging, although not automatic, is usually classified as such because it is new and different in lease operation. Figure 4 shows a remote gaging panel which enables the pumper to keep track of 14 tanks in 5 batteries which are located at distances up to several miles from the gaging point.

The tank gage and transmitter which send information to the gaging panel are shown in the right-hand part of Figure 4. This system, in conjunction with automatic tank switching, effectively reduces the pumper's time and mileage required to operate each battery.

Custody Transfer. Automatic custody transfer represents a new philosophy in lease operation, based on a relatively continuous delivery of the produced oil to the pipeline outlet. This is opposed to the conventional method of accumulating the produced oil in lease tankage and periodically deliverying the oil manually to the pipeline. As a result, a worthwhile re-

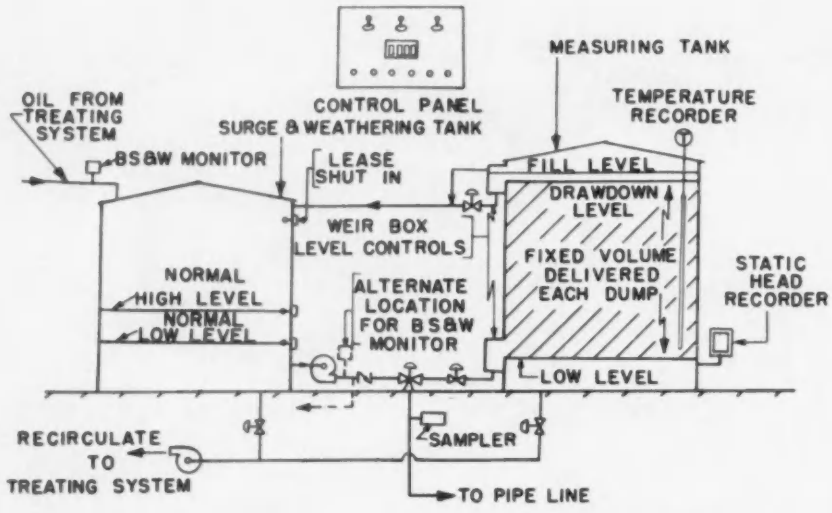


FIGURE 5—Automatic custody transfer battery single measuring tank.

duction in the number and size of lease storage tanks can be made. In many instances, the savings in tankage will pay for the automatic installation.

Worthwhile labor savings are also effected because the pumper is relieved of the work of topping out and switching tanks, recirculating tank bottoms, etc.

A further advantage accrues from the fact that with the advent of automatic custody transfer, it becomes possible to equip a lease for fully automatic operation from the well to the pipeline outlet, including safeguards which will monitor the operation and shut in the entire lease in case of trouble.

This greatly reduces the manual supervision required and makes possible the economic utilization of numerous minor automatic devices which cannot be justified as long as the pumper must visit the battery at frequent intervals and can do these minor jobs while he is there. By eliminating these frequent trips, a payout on these various minor devices can be obtained.

The method is particularly applicable to consolidated batteries in unitized secondary-recovery operations which are daily becoming more numerous. In these operations, production usually increases as the flood progresses, requiring the addition of tankage to handle the larger volume of oil. In this situation, automatic custody transfer can usually be installed with less expenditure than would be required for conventional tankage.

Developments in automatic custody transfer are occurring rather rapidly at present because of the widespread attention and study being given to the problem by various operators and by equipment suppliers. A number of such batteries are in operation at present on a shakedown basis to establish satisfactory operation before starting unattended automatic operation. Many others are in the planning stage.

The principal problems involved in this type of operation include:

1. The provision of a treating system which will provide merchantable oil to the automatic custody transfer system so that rejected oil is held to a minimum.

2. The accurate measurement of the volume, temperature, gravity, and BS&W of the oil delivered.

3. The reliable recording of these measurements.

4. The rejection and recirculation of non-merchantable oil.

5. Protection of the installation against environmental conditions such as cold weather, corrosive conditions, paraffin deposition, tampering, etc., to insure reliable operation under all conditions.

6. The provision of manual controls for emergency or special operation, arranged in such a way that their use will not result in false recording or improper operation of the system when restored to automatic control.

7. Provision for scheduling deliveries in accordance with lease allowables and pipe line batching requirements where this is necessary.

8. Provision for manually checking the operation of the unit with commonly available tools.

9. Sufficient flexibility to meet changing conditions such as the normal changes which occur during the life of a well, seasonal changes, changes of allowables, etc.

10. Provision of an over-all system which is adequate to perform the required operations and yet simple

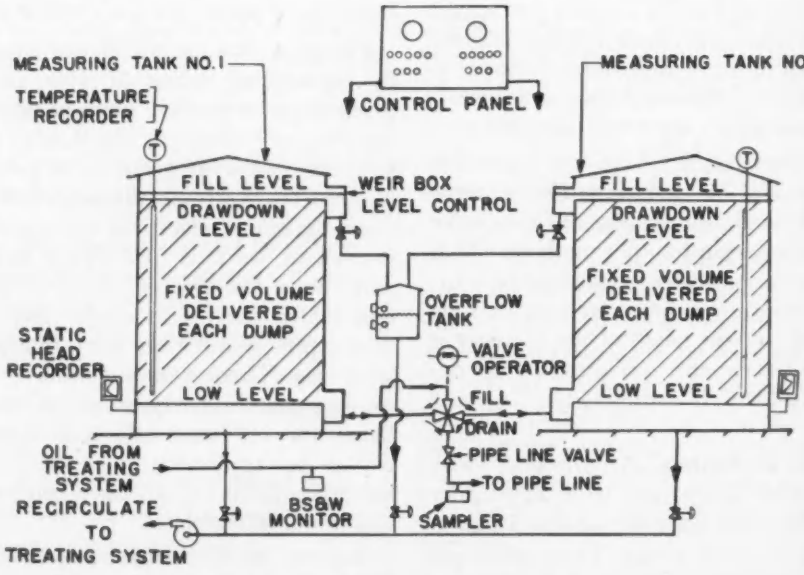
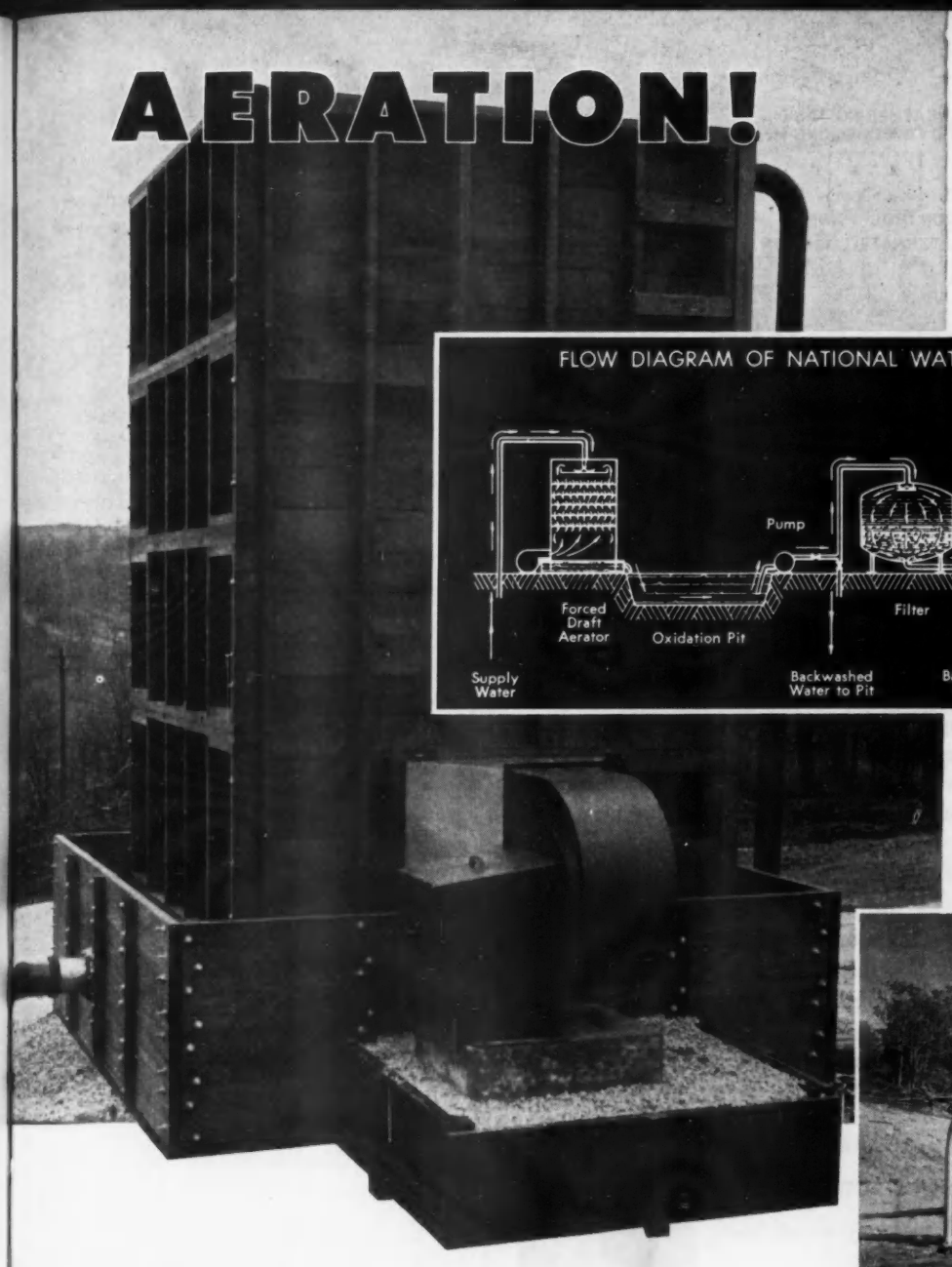
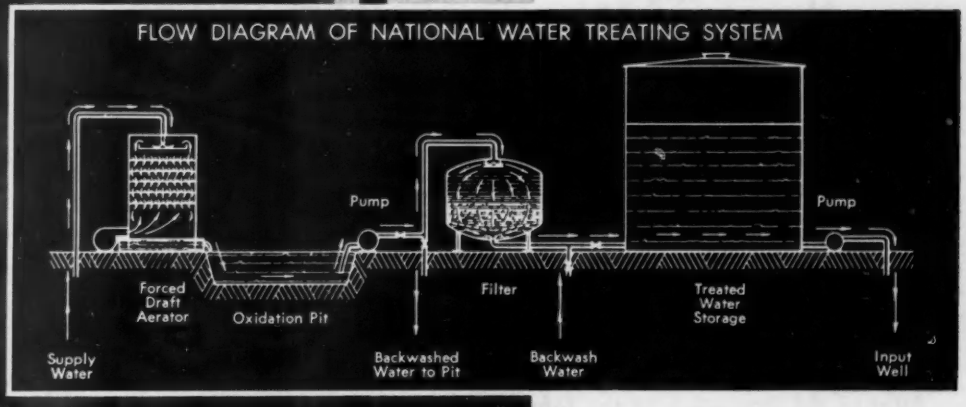


FIGURE 6—Two-tank automatic custody transfer battery.

AERATION!



National Aerator for treating supply water or disposal water in open water system.



Two National Aerators in series with water supply well located north of Tulsa, Oklahoma.

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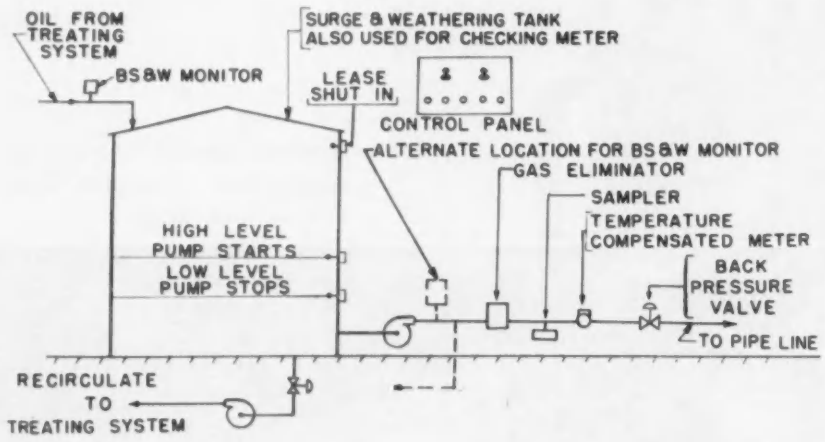

FIGURE 7—Automatic custody transfer battery volume measurement by positive displacement meter.

enough to be feasible from the economic and operational viewpoint.

Within the framework of the foregoing requirements, many arrangements are possible. However, on the basis of experience, it appears that three arrangements may emerge as the principal types of automatic custody transfer battery.

These are (Figure 5) a single measuring tank arranged to deliver a fixed volume for each delivery, (Figure 6) a system using two measuring tanks in which one tank fills while the other drains, with each tank delivery a fixed volume, and (Figure 7) a system using a surge tank to accumulate the production and positive displacement meter to periodically run the accumulated oil to the pipe line.

In the tank systems, the fixed volume delivered is determined by overflow weirs set at high and low levels in the measuring tank. These devices appear to offer the best long-term accuracy and trouble-free operation available at present and have met with ready acceptance in most quarters because they offer an accuracy which approaches the accuracy of the tank calibration itself.

In the system using a meter to measure volumes, a number of safeguards are necessary to assure the best results. These include strainers, air and gas eliminators, a back-pressure valve to maintain a positive head on the meter, and some form of flow control to keep the flow rate within the accurate range of the meter. In addition, some form of proving device must be provided for regularly checking the accuracy of the meter. A great deal more reluctance has been shown in accepting the meter system than the tank systems.

Automatic custody transfer batteries are more complicated than standard manually operated batteries. They require less manpower to operate but are more complicated when repairs are needed. This fact will undoubtedly result in a number of changes in the operational setup now used at manual batteries. A regular program of maintenance will be required; one skilled worker may eventually replace several less skilled; and a fail-safe shutdown system will probably replace the constant manual surveillance now used.

Pipe line companies have shown a keen interest in automatic custody transfer because they see potential savings in gagers' time and better scheduling of runs for more efficient use of their lines.

They recognize such design problems as:

1. Provision of adequate weathering time prior to measurement, to reduce evaporative losses in their system.

2. Adequate safeguards against tank-bottom buildups.

3. Rejection of non-merchantable oil.

These requirements are adequately met by existing designs and there does not appear to be a serious problem here.

Representatives of state regulatory bodies, generally speaking, have taken a favorable view of the automatic custody transfer method when approached informally, but have pointed out several requirements that must be met before such operations can be inaugurated on a regular basis. Among these are:

1. Some provision must be made to limit monthly deliveries to the amount of the allowable.

2. A "shakedown" period must be satisfactorily completed before final approval can be given.

3. Some states will require public hearings and formal approval because the method of delivery conflicts with existing regulations.

In recent months, several oil field suppliers have set up active departments to handle equipment and problems involved in lease automation and new items of equipment are appearing on the market daily in answer to the needs of the industry. Also, several companies are now prepared to make field installations on a turn-key basis with suitable performance guarantee, free service for a shakedown period, and service thereafter at established rates. This approach will no doubt accelerate the application of automatic controls.

ACKNOWLEDGMENT

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About the Author

L. M. HUBBY joined The Texas Company in 1935 after receiving a B.S. degree in electrical engineering from Texas A&M College. He spent 12 years in geophysical exploration, transferred to the Texas Company Laboratories in Bellaire, Texas, in 1947, and was assigned to the staff of the chief petroleum engineer, Producing department, in 1953. At present he is petroleum engineer in charge of automation.

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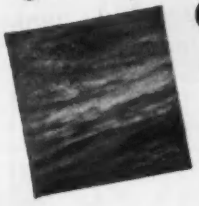

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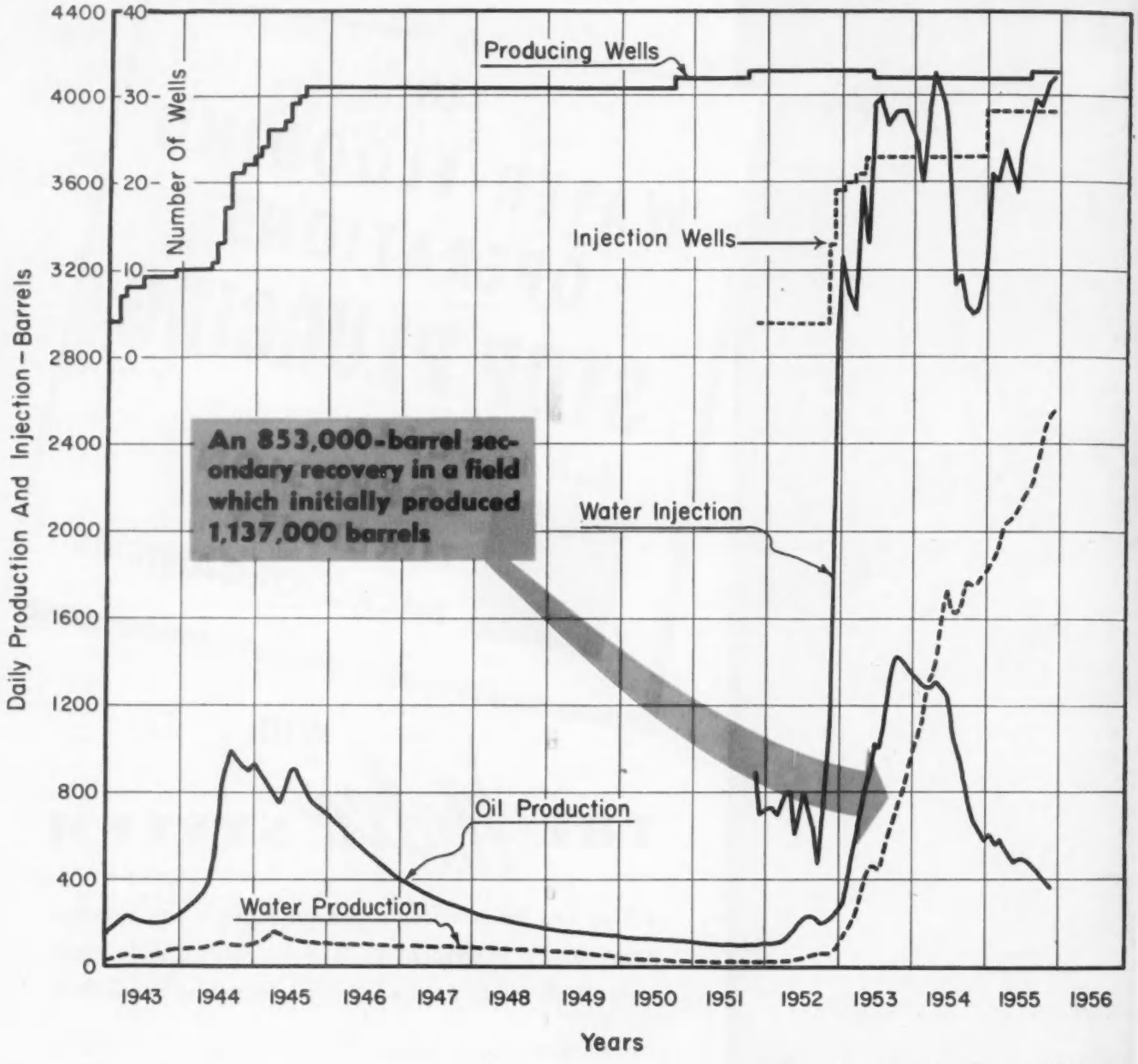


This performance curve shows production statistics of Waltersburg Sand, Uniontown waterflood project.

Uniontown Hits Water-Flood Jackpot

Here's how a water transfusion brought a dying field back to life. Included is a description of flood development, facilities and equipment.

By KENNETH E. BARNETT and JERRY R. VAUGHAN
Sun Oil Company, Evansville, Ind.

WATER-FLOOD programs meet with varying degrees of success or failure, but the one in the Uniontown Consolidated field of Kentucky produced results that will prick the interest of any producer.

The results: an 853,000-barrel secondary recovery in a field which initially produced 1,137,000 barrels. How was it accomplished? Here is a brief picture of the geology of the area, a description of the flood development, information on reservoir characteristics, water-flood facilities and equipment, and an evaluation of the results.

The Uniontown Consolidated field is an anticlinal structure located on

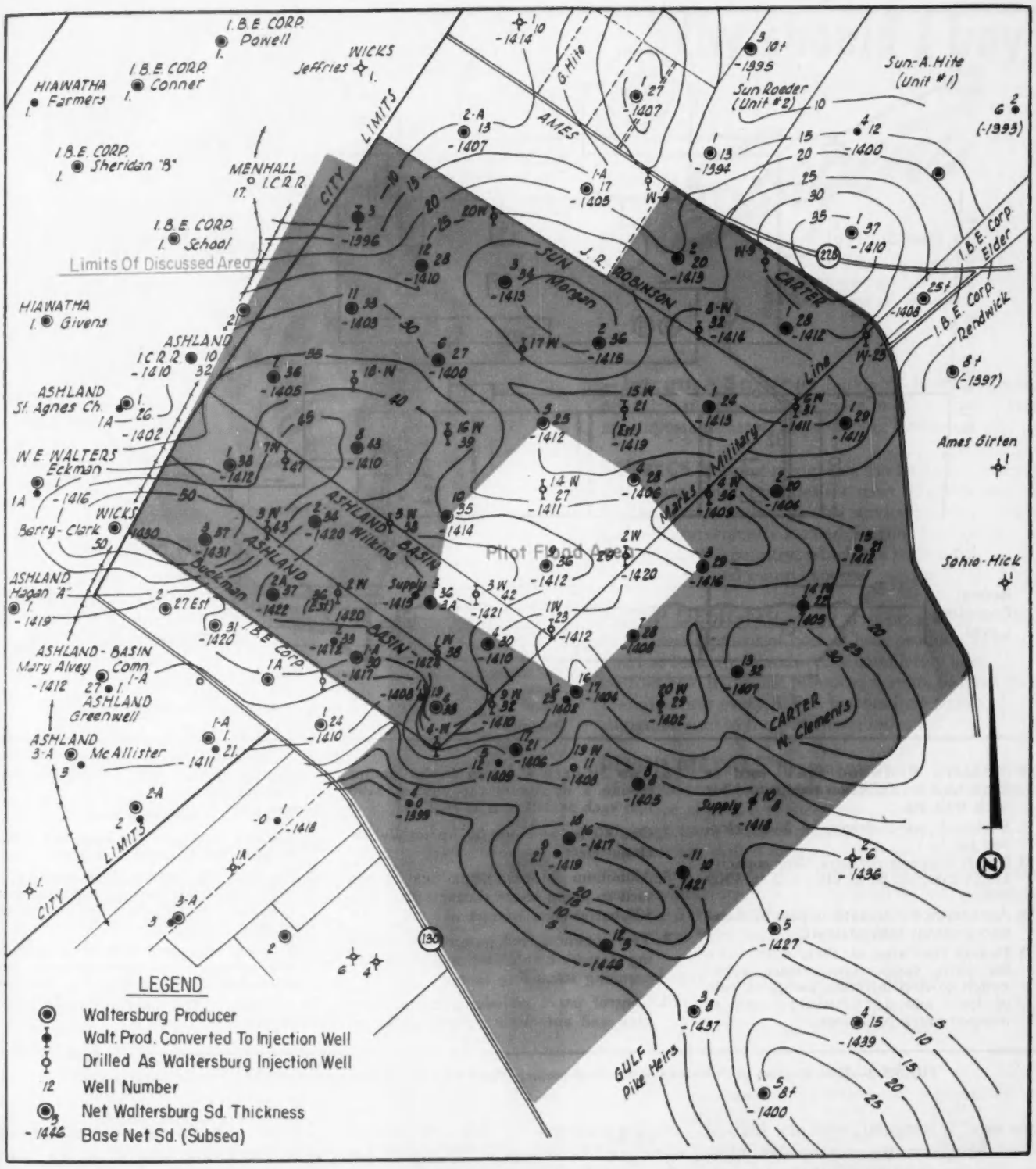
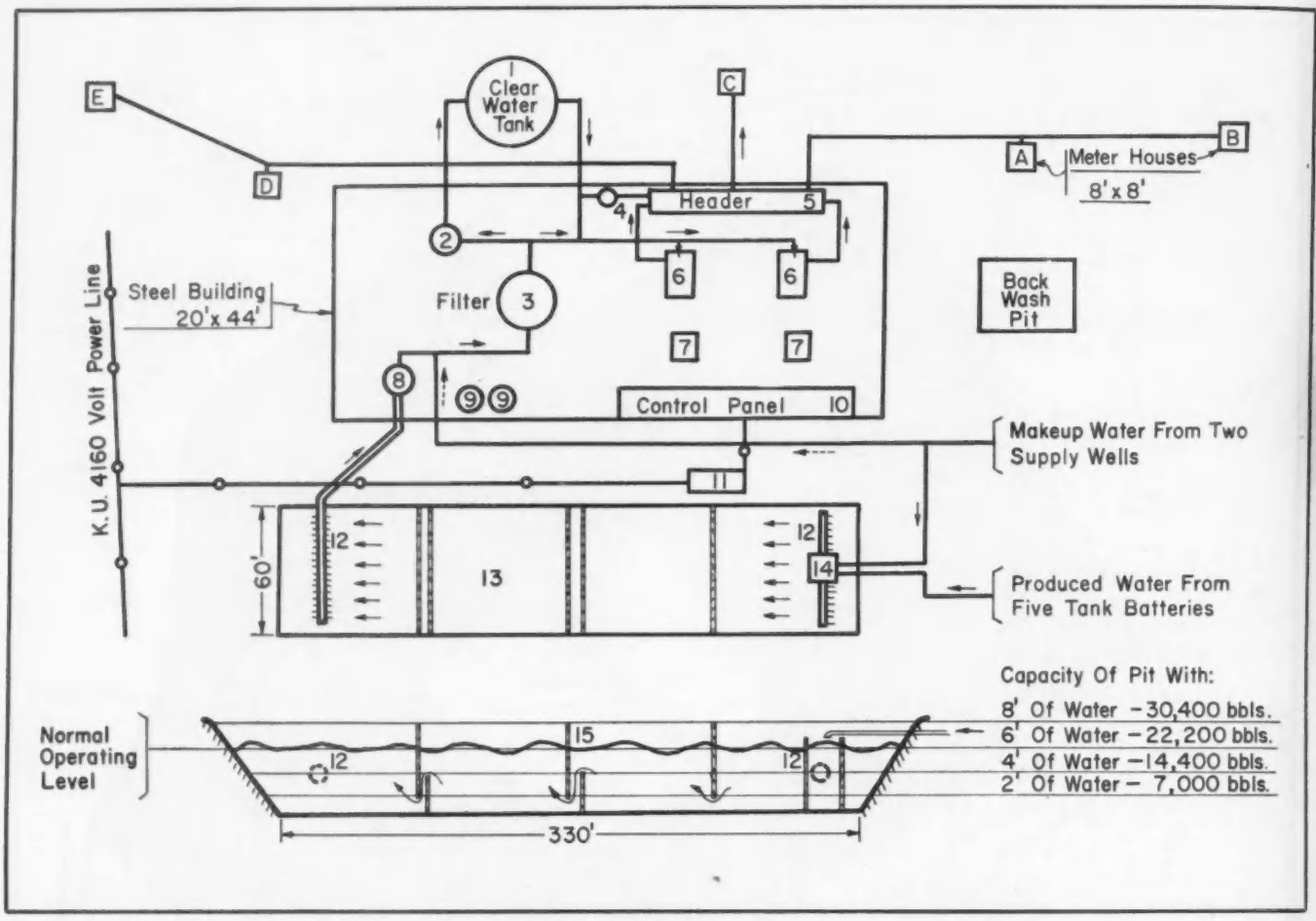


FIGURE 1—The Uniontown pool. Colored area denotes limits of area discussed here. In the center is the pilot flood area.

the regional dip. There is no surface indication of a structure over the field. The structure was originally mapped from coal information as a north and slightly eastward nosing. The field lies as a north-south elongated dome, with closure on the west against the upthrown side of a normal fault. To the north, east, and south, the Waltersburg sandstone dips off into water.

The Little Menard lime, on the average for the field, lies 20 feet above the Waltersburg sandstone. There are 48 feet of closure on the little Menard lime. The several minor irregularities present on the top of the lime are due almost entirely to the irregular thickness of the Waltersburg sand. Production is minor, or even absent, in the depressed areas. As much as 57 feet of productive sand is present over parts of the field.

With a few exceptions the Waltersburg sandstone is productive over the entire field and comprises an area of approximately 2000 acres. The sand is fine-grained, fairly firm, and in general carries very thin, irregular shale and residue partings. Locally, the sand is clean and friable. In a few areas the sand has streaks of lower permeability which will give up water along with the oil. The water level for



1. 500-barrel Redwood tank—used as surge tank for injection pumps and for back washing.
2. Backwash pump driven by 20-hp electric motor.
3. 8-inch diameter pressure filter capacity at 2.5 gpm/sq. ft. of filter bed in 4300 bpd.
4. Air-operated automatic bypass to maintain constant tank pressure.
5. Header consisting of: shear relief valve for each pump; low-pressure safety switch to stop injection pumps in case of leak; and accumulator used to dampen pump pulsations.
6. Two 2¼-inch x 5-inch triplex pumps having a maximum capacity of 3190 bpd each at 360 rpm at 1640 psi.
7. One 60 hp and one 50 hp totally enclosed electric motors.
8. Aluminum bronze centrifugal pump used to pump water through filter into 500-barrel clear water tank.
9. Two chemical feed pumps, one pumping corrosion inhibitor and the other pumping stabilizing agent.
10. Control panel includes starting, stopping and automatic equipment for all electric motors and submergible centrifugal pumps.
11. 150 KVA transformer bank.
12. Six-inch pipe used for inlet and outlet to pit. Pipe is perforated across pit.
13. Pit used for mixing and settling of water prior to filtering and also as a reservoir for supply and produced water.
14. Five-foot square wooden box used to mix produced and make-up water. Box is connected to 6-inch perforated pipe.
15. Wooden baffles used to divert water in pit.

FIGURE 2—Flow diagram of Uniontown water-flood project. Numbers above indicate corresponding installations in project.

the sand is irregular, with the highest level being on the north, the intermediate level being on the southeast, and the lowest water level being on the southwest.

Primary Development. The Uniontown Consolidated field was discovered in September, 1952, when Sun Oil Company drilled the Hite Unit 1, Well 1, in 16-P-20. This well was completed for an initial production of 361 barrels per day from the Waltersburg sand, at a total depth of 1845 feet, plugged back.

The field was drilled on a somewhat regular 10-acre spacing. The portion covered by this article was developed by August, 1945, except for three infill producing wells that were drilled after initiation of the water-flood program. The wells in this area initialed from 27 to 300 barrels of oil per day, and a maximum Waltersburg production of approximately 1,000 barrels per day for the area discussed was reached in September, 1944. The production had declined to less than 80 barrels per day at the time the pilot flood was initiated.

Most of the wells were drilled with rotary tools. Casing was set at or near the top of the sand in the single completion wells. In the dual completion wells the casing was set at the lower formations, with a special section opposite the Waltersburg sand. After the casing was cemented, cable tools were used to drill plug, shoot, clean out, and put the well on production.

Water-Flood Development. In January, 1949, a meeting of the operators was held for the purpose of initiating a pilot flood in the Waltersburg sand. The area selected for the pilot flood was near the southeast corner of the Sun Oil Company's Morgan lease.

The operating agreement under which the pilot flood and a limited

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•

Positive detachable standing valve puller. (Tubing Pumps.)

•

Rod Rotator.

•

Safety sucker rod wrench.

•

First rod insert liner pump which could be removed on sucker rods without pulling tubing.

•

Long stroke sub-surface hydraulically operated pump.

•

Sucker rod hanger.

•

Sucker rod elevator.

•

Hard stainless steel pump liners and plungers.

•

Automatic rod hook-on attachment.

•

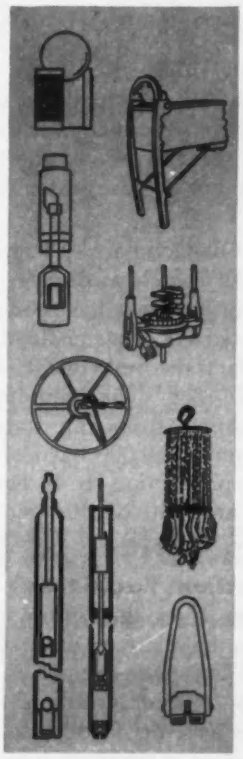
Bottom support tubing liner pump.

•

Pressed-in liner pumps.

•

Sub-surface dynagraph.



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• "GOOD WILL" is the disposition of the pleased customer to return to the place where he has been well treated.
U. S. Supreme Court

expansion of same were to be conducted, consisted of the following basic factors:

- The project was to be on a cooperative basis; there would be no unitization of royalty interests.
- An approximate 10-acre, 5-spot pattern would be developed by the drilling of lease line injection wells. (See Figure 1) Each line injection well would be jointly owned by the operators owning the leases adjoining the lease line on which the well would be drilled. Inside injection wells were to be owned 100 percent by the lease operator.
- The percentage ownership in the water supply, treating, and injection facilities was arrived at by determining each operator's percentage of acre-feet of Waltersburg sand within the areas to be served by these facilities.

Injection into the four pilot wells was started in November, 1951, some 34 months after the first meeting was held to initiate the project. The first increase in production was noted in the Ashland-Basin Wilkins Well 4, which was not drilled until October, 1951. There was a gradual increase in oil production from the other wells in the immediate area; however, it is interesting to note that the Wilkins 3 well was one of the last wells to be affected in the area as a result of the pilot flood, yet it is the closest producer to an injection well.

It is known that considerable water "fingered-out" of the pilot flood area, as the total volume of water injected was more than sufficient to fill the total void space, and the total fluid being produced at the time was considerably less than the daily injection rate.

Nineteen more injection wells were completed by June, 1953. During this time the plant facilities were expanded to take care of the additional injection wells. The flood was not expanded as rapidly as it should have been for keeping the flood in balance and for most efficient overall operation. Five injection wells along the north limits of the area were not drilled until December, 1954. Injection rates were cut back from April, 1954, until these wells were completed. (See performance curve.)

Reservoir Characteristics. Listed below are the original reservoir characteristics, as determined from 401 feet of core from 16 wells in the area now under flood:

Original bottom-hole pressure, estimated . . . pounds per square inch	720
Bottom-hole pressure at begining of flood, estimated . . . pounds per square inch	10
Bottom-hole temperature . . . degrees Fahrenheit	82
Formation volume factor	1.07
Viscosity @ reservoir temperature . . . centipoise	5
Gravity, API . . . degrees	38
Porosity . . . percent	18.4
Permeability . . . millidarcys	90
Initial oil saturation . . . percent	70
Connate water saturation, estimated . . . percent	30
Residual oil saturation after waterflooding . . . percent	18.7
Relative permeability to brine @ residual oil saturation	.095
Brine permeability at 100 percent brine saturation . . . millidarcys	80

WALTERSBURG RECOVERY

Primary recovery (barrels)	1,137,000
Primary recovery (barrels per acre-foot)	118
Primary acre-feet (total all leases)	9,620
Surface area (acres)	388
Average thickness (feet)	25
Secondary recovery (barrels)	853,000

Primary oil production from this area has been due principally to a solution gas drive. Production from a few wells on the east side of the field gives evidence of a slow water drive on that side.

The Sun Oil Company Morgan 9 producing well, which was in the center of the pilot five spot, has produced some 36,600 barrels of water-flood oil, for a secondary recovery of 135 barrels per acre-foot. The cumulative water production from the start of water injection is 110,000 barrels, and the current production is 8 barrels per day oil and 140 barrels per day water.

Water Injection Facilities. The flow of water from the supply wells and through the plant is outlined in Figure 2. The water supply is obtained from a Pennsylvanian sand which occurs at a depth of 1350 feet and has a sand section of approximately 80 feet in this area. Two temporarily abandoned Cypress wells were plugged back and recompleted as water supply wells. The wells were perforated opposite the sand section. After perforation with 100 shots, one well tested 600 barrels per day by swabbing to 1200 feet. Another 40 shots did not change the capacity of the well. The well was then acidized with 1000 gallons regular acid. After acidizing, the well produced 1900 barrels per day with a drawdown of approximately 400 feet in fluid level. This well has produced 1,400,000 barrels with no apparent increase in the amount of drawdown. It is now used as a stand-by well.

The second supply well was completed in the same manner as the first, with the exception that it was not acidized. Its initial producing rate was approximately 2200 barrels per day, with 1100 feet of drawndown. The cumulative water production to December, 1955 was 1,150,000 barrels. This well has shown some decrease in productive capacity. The well was equipped originally with a 37½ horsepower submergible centrifugal pump, which was replaced in May, 1954, with a 22½-hp pump.

These two wells supplied all the water injected during the first 1½ years of the flood. When large quantities of water were produced with the oil, it became desirable to use this produced water for injection. The produced water currently comprises ¾ the volume of water injected daily. This produced water is primarily Waltersburg, but also includes approximately 100 barrels per day Cypress and Tar Springs produced water.

Before using the produced water for injection, it was mixed with the raw water from the supply wells, in order to determine its compatibility with the supply water. Samples of Waltersburg sand, obtained by diamond coring, were tested for throughput rates. No serious plugging or swelling of the cementing material in the sand was noted in the samples tested.

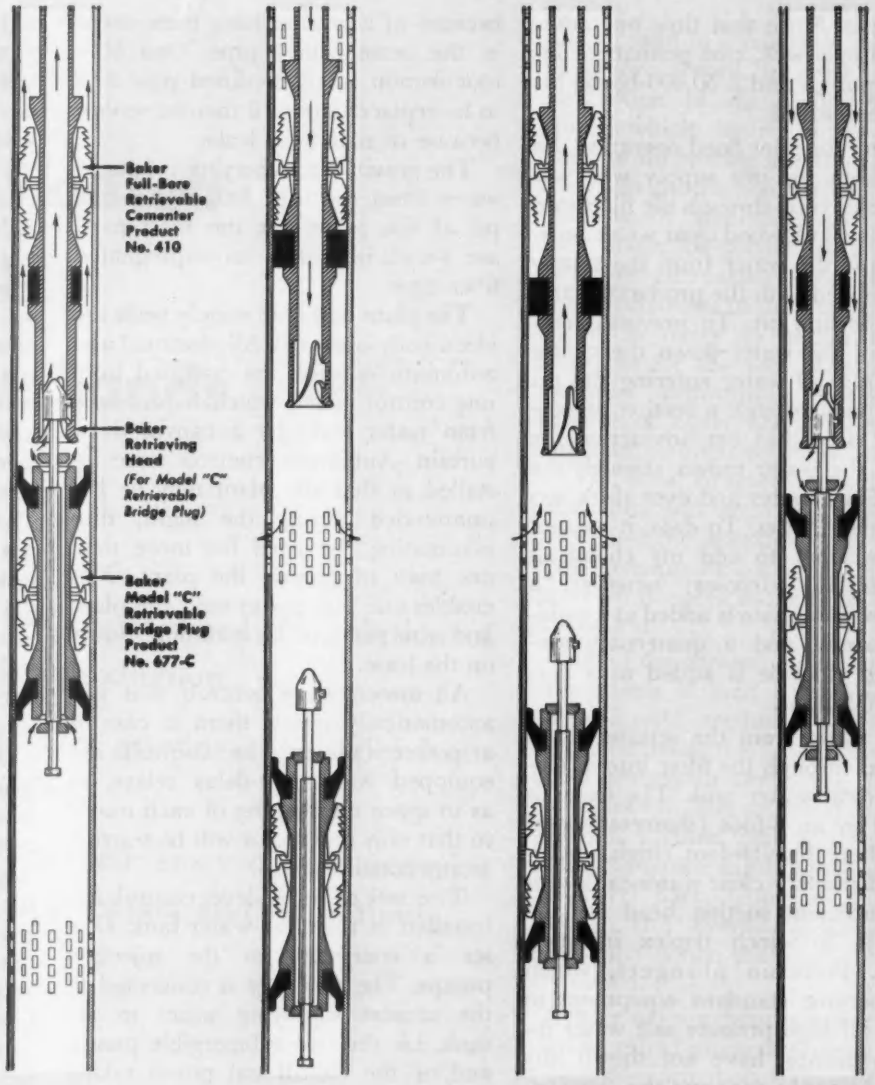
Listed below are the results of water analyses:

	Raw Supply Water	Waltersburg Produced Water
pH	7.4	7.4
Carbon dioxide, p.p.m.	19	17
Dissolved oxygen, p.p.m.	0.0	No data
Turbidity, p.p.m	1.4	Very high
Sulfates, p.p.m.	2,814	110
Iron (total), p.p.m.	7.5	20
Methyl orange alkalinity, p.p.m.	128	480
Chlorides, p.p.m.	16,680	35,050
Soap hardness, p.p.m. $CaCO_3$	3,880	1,740
Silica, p.p.m.	8	5
Calcium, p.p.m.	1,200	352
Magnesium, p.p.m.	202	207
Barium, p.p.m.	2.9	0.0

A temporary pump was used to inject water for six months into the four

TYPICAL OPERATION

Product No. 410


Baker Full-Bore Retrievable Cementer Product No. 410
Baker Retrieving Head (For Model "C" Retrievable Bridge Plug)
Baker Model "C" Retrievable Bridge Plug Product No. 677-C

RUNNING-IN
Retrievable Bridge Plug being run into well on bottom of Full-Bore Cementer through use of Retrieving Head. Note fluid by-pass.

FRACTURING OR ACIDIZING
Plug should be pressure tested after release. Cementer is released, raised above perforations and reset for pressure operations.

SWABBING, TESTING
Note how the reversal of pressure differential has transferred load from one set of slips to the other (both cementer and plug).

RETRIEVING
Plug and Cementer being moved to next set of perforations—or retrieved from well. Valves in plug open to permit fluid by-pass.

BAKER FULL-BORE RETRIEVABLE CEMENTER

HOLDS PRESSURE FROM EITHER ABOVE OR BELOW

Two sets of opposed slips enable the cementer to hold pressure from either above or below. Casing can be tested before squeeze—and the tubing also, if the Baker Full-Bore Tubing Tester is used.

FULL BORE CONSTRUCTION

Permits Passage of Tubing Perforators or Instruments—Assists in Preventing "Screen-Out" on Fracturing Jobs

The Full Bore through the Cementer (and Tester if used) is in reality a continuation of the bore through the tubing.

This continuous full ID passage not only permits passage of tubing perforators or instruments but assists in preventing "Screen-Out" (sand dropping out of the oil) and subsequent plugging of the tubing in fracturing jobs.

IDEAL STRADDLE TOOL WHEN USED WITH BAKER RETRIEVABLE BRIDGE PLUG

The operation of the Cementer setting mechanism makes it easy (through the use of the Retrievable Bridge Plug Retrieving Head) to release and pick-up the Baker Retrievable Bridge Plug. It is in fact the ideal partner to the Retrievable Bridge Plug for selective multiple-zone or single-zone operations.

these products and their application

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pilot wells. Since that time one additional supply well, two permanent injection pumps and a 30,400-barrel pit have been added.

During the pilot flood operation the water from the one supply well was pumped directly through the filter into a 500-barrel redwood clear water tank. Currently, the water from the supply well is mixed with the produced water in the settling pit. To prevent channeling of the water down the center of the pit, all water entering the pit has to pass through a section of perforated pipe that extends across the pit. As the water moves through the pit, it flows under and over three sets of wooden baffles. To date, it has not been necesary to add my chemicals for treating purposes; however, a complex phosphate is added as a stabilizing agent, and a quaternary ammonium chloride is added as a corrosion inhibitor.

The water from the settling pit is pumped through the filter into a 500-barrel clear water tank. The water is filtered by an 8-foot (diameter) steel shell filter. The 16-foot (high) x 16-foot (diameter) clear water tank supplies sufficient suction head for the two 2¼ x 5-inch triplex injection pumps. Porcelain plungers, which have become standard equipment in nearly all high-pressure salt water injection pumps, have not shown any signs of wear to date and the chevron-type packing has given good service. Three porcelain plungers have been replaced because of tensional failure of the steel core in the center of the plunger.

When the second injection pump was added, the vibration due to fluid pulsation became rather critical. The 2½ x 3-inch high-pressure swage screwed into the discharge of this pump broke on several occasions. The discharge piping in the plant and the header in the meter houses had to be well-braced immediately. A 2½-gallon accumulator (pulsation dampener) was installed on the header in the plant. This accumulator is equipped with a rubber bladder and is preloaded with nitrogen gas to approximately 60 percent of the plant pressure. The bladder-type dampener was very effective in this particular installation.

The water supply and injection lines, with the exception of one 2-inch plastic-lined pipe, are either 2-inch or 3-inch cement-lined pipe. No leaks because of corrosion have been noted in the cement-lined pipe. One 600-foot section of plastic-lined pipe had to be replaced after 18 months service because of numerous leaks.

The gravity lines carrying produced water from the tank batteries to the pit at the plant, for the most part, are 4-inch or 6-inch tar-impregnated fiber pipe.

The plant and both supply wells are electrically operated. All electrical and automatic controls are operated from one control panel, which is protected from water leaks by a canvas draw curtain. Automatic controls were installed so that the plant may be left unattended during the night, thus eliminating the need for more than one man to operate the plant. This enables one pumper to tend the plant and also perform his pumping duties on the lease.

All motors have controls that will automatically restart them in case of a power failure. The controls are equipped with time-delay relays, so as to space the starting of each motor so that only one motor will be starting at any certain time.

Two sets of liquid-level controls are installed in the clear water tank. One set is connected to the injection pumps. The other set is connected to the sources supplying water to the tank, i.e. the two submergible pumps and/or the centrifugal pump taking water from the settling pit. This set of controls is interchangeable between these two sources.

A low-pressure killer switch, installed as a safety device, will automatically shut down the injection pumps whenever injection pressure is lost because of a leak in an injection line. The loss of injection pressure due to failure of electric power will not activate this switch.

Safety devices installed to compensate for high pressures include a shear-relief valve on the discharge line of each injection pump. An air-operated regulator valve is installed in the by-pass line from the header to maintain an even injection pressure on the system.

The injection wells were drilled with rotary tools. Five and one-half inch casing was set on top of the pay and cemented to the surface. All the injection wells were shot with approximately 2½ quarts of nitroglycerin per foot. The injection rate into one of the pilot wells was only 20 barrels per day at 800 pounds per square inch prior to shooting. Immediately after shooting, the injection rate was 350 barrels per day at 10 psi. The current injection rate is 220 barrels per day at 1000 psi. Water is injected directly into the casing, with the exception of three wells where tubing and packer have been installed. These three wells were producing wells that were converted to injection wells.

Two injection wells have been sand fractured in an effort to increase the injection rate. The injection rate into one well increased from 30 barrels per day to 50 barrels per day, and is currently (two years later) taking 40 barrels per day. The other well increased in injection rate from 5 barrels per day to 25 barrels per day, but showed a much steeper decline in injection rate. Four wells have been acidized with 1000 gallons of 25 percent HCl. This resulted in an immediate increase in injection rate to approximately ⅔ the rate at or near fill-up. However, this rate is not sustained, and declines within a year to the rate before acidizing.

Water is currently being injected into 28 wells at an average rate of 140 barrels per day per well. The surface injection pressure varies from 0 to 1000 psi, and the rates vary from 30 to 230 barrels per day. The cumulative injection of 4,330,000 barrels for the 28 wells gives an average cumulative injection of 155,000 barrels for each well.

The desired injection rate for each of the injection wells is based on 0.7 barrel per day per acre-foot of sand the well serves. However, in a few cases this desired rate is not attained because of low permeability.

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ACKNOWLEDGMENTS

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How Plastic-Coated Walnut Shells Control Loose Sands

• Here's another step toward the solution of sand problems in petroleum production.

• Case histories are proving that relief from the problems is being provided.

• This is the complete story of the material . . . including methods of application and limitations.

By J. K. HENDERSON, W. L. SALLEE and C. M. STOUT
Dowell Incorporated, Tulsa

THE SUCCESS of the plastic-coated walnut shell method of sand control has been outstanding. Few failures have been experienced, positive sand control having been secured in practically every case. In addition, the use of plastic-coated walnut shells has certain distinct advantages over other methods of sand-control:

- Ease of application. This technique is no more complex than a fracturing treatment. The same service equipment is used for both types of well treatments.
- Production stimulation. Not only is production restored by effective control of formation sand, but as a result of this treatment, may exceed initial production.
- Applicable to dual completions. Both zones may be treated easily and effectively.
- Elimination of costly fishing operations. Conventional screens are not employed.

The production of oil from incompetent formations has long been a major problem with petroleum engineers. The movement of sand into the well-bore with well fluids will, in many cases, choke off oil production entirely.

Although many methods of controlling sand have been devised, no single method has proved 100 percent successful. In areas where the sand control problem is not acute, the open hole has been increased in size by under-reaming. In wells where the hole is cased to bottom, a similar effect has been achieved by increasing the number of perforations.

In some cases, a well completed in an incompetent sand will stop producing sand in a relatively short time, of its own accord. In other cases, the production of oil is limited by a choke, which, by restricting the velocity of oil moving into the well-bore, allows its production without a great quantity of accompanying sand. In later stages of production, however, as water encroaches upon the well, greater amounts of fluid must be produced in order to obtain the full allowable for the well. The resulting increased drawdown increases the amount of water and oil produced, which in turn carries more sand into the well bore. In severe cases, limiting production will not correct the difficulty, and the operator must depend upon cleaning out his well at frequent intervals, in order to maintain desired production.

One of the earliest, and most popular methods of sand control was the "gravel pack" method. The gravel pack held back the loose, unconsolidated sands while permitting the production of oil. The principal difficulty with this method was the tendency for the formation sand to migrate into the gravel pack, filling up the flow passages and eventually causing a check-valve action that shut off all oil production.

A later development was the use of graded, round-grained Ottawa sand to pack the formation. The sand pack was held in place around the well bore by a perforated metal liner. This injected sand was designed to hold back the finer formation sands, yet have sufficient permeability to allow the production of oil from the formation.

Still another solution to the sand control problem has been the use of sand consolidation plastics, designed to bond the unconsolidated sand grains together, yet leave enough residual permeability in the formation for the oil to flow into the well-bore.

Each of these methods has its own advantages and disadvantages, and the search for more efficient and economical methods of sand control has continued. The most recent development has been the use of plastic-coated walnut shells.

In this method, ground and graded walnut shell particles are first coated with an unset thermo-setting plastic. These particles are next injected into place in the formation by means of an oil carrying agent. Once in place, the particles are kept motionless until

the plastic can set, cementing the individual shells together and forming a highly permeable consolidated network. These treatments are not complicated, requiring no special equipment, other than that used for conventional hydraulic fracturing treatments.

By pre-coating the walnut shells before they are pumped into the well, a minimum of plastic is used, and the operator is assured of maximum residual permeability through the consolidated walnut shell network. The success of this treatment is not dependent upon shrinkage of the plastic, or flushing another fluid through after the network is in place, as in other sand consolidation plastic methods.

Materials. The three materials used for this new sand control method are: crushed and graded walnut shells, a thermo-setting plastic, and a suitable carrying oil. The specific materials used were selected, after extensive laboratory testing, as being the most advantageous for this service.

The graded walnut shells were found to have a high affinity for the uncured plastic. This minimized the possibility of some of the plastic being washed off of the shells by well fluids, or the oil carrying medium. In contrast, it was found that sand had a much lower affinity for the plastic. Consequently, an uncured plastic coating could be easily removed by the oil carrying medium. It was also found that the bonding strength of the cured plastic to the walnut shells was far superior to that of the plastic when bonded to sand.

The crushed walnut shells also have other favorable characteristics. Their density is approximately half that of sand, so that on a pound basis, they occupy twice the volume that an equal weight of sand would occupy. Because of their extreme toughness, they are highly resistant to crushing.

One of the most interesting advantages of the use of ground walnut shells results from their angular shape. It appears that the irregularity of the graded particles prevents their packing in optimum arrangement. The resulting random packing subsequently yields a high permeability. The tackiness of the plastic coating on these shells tends to make them stick to one another, and is an additional factor in preventing close, maximum packing. This has been demonstrated in the laboratory by comparative permeability tests on coated and uncoated walnut shell particles, as shown in Table 1.

The angularity of the walnut shell particles, and the randomness of their arrangement in the network, appears to be highly favorable in preventing the migration of fine formation sand. Laboratory tests have shown that two inches of walnut shell network will initially produce 140 to 300 mesh sand. The resulting eventual bridging of this sand prevents further sand migration. Unlike other sand control methods, however, these tests have shown that a residual permeability of from 4 to 10 Darcys remains in the bridged area, after the fine sand production has ceased.

A phenol-formaldehyde plastic was found to be best suited for this sand control service. This plastic has the advantage of being usable over a wide range of well temperatures (70° F. to 280° F.) and, through the use of proper catalysts, controlled setting times are obtainable over this entire temperature range. This plastic, when set, has the added advantage of being inert to all types of well fluids. As previously mentioned, the plastic in its uncured liquid form, has a high affinity for the walnut shells, so that it is not readily removed by the oil carrying medium.

Tensile and compressive strength tests of consolidated walnut shell networks showed them to be comparable to many hard rock, oil-producing formations. (Average tensile strength of the test specimens was 150 pounds per square inch; compressive strength, above 2000 pounds per square inch.) In other tests, exposure to brine and crude oil at 160° F. for six months resulted in no change in strength or permeability of the plastic-walnut shell network.

Considerable variation has been found in the permeabilities of the set plastic-walnut shell combination. This is undoubtedly due to differences in the degree of packing which the walnut shell particles undergo before the plastic hardens. One of the governing factors is the pressure under which these shells are set; the greater the pressure, the more closely together the shells become packed.

TABLE 1
Comparative Permeabilities of Various Sand Control Agents

AGENT	Permeability (Darcys)
20-40 mesh Ottawa Sand	100 to 130
20-40 mesh walnut shells	160 to 180
Plastic-coated, 20-40 mesh, walnut shell network	300 to 700

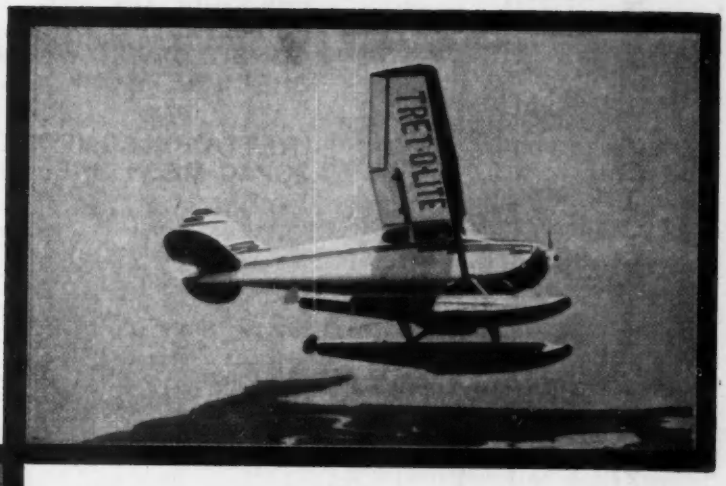
Note: Permeability measured using oil with 3 cps. viscosity.

Laboratory tests were run to determine whether too much pressure might result in reducing the permeability of the consolidated walnut shells to zero. For these tests, a number of batches of unset plastic and 20-40 mesh walnut shells were used. If allowed to set at atmospheric pressure, the resulting cores had a permeability of 300 to 700 Darcys. These cores were subjected to different pressures for a five-minute period, following which the pressure was released and the plastic allowed to set up. The purpose of this test procedure was to simulate reaching a final squeeze pressured during a well treatment, followed by bleeding off the pressure to static conditions. The results of these tests are shown in Figure 1. As may be seen, permeability remained open, up to and including pressures of 7500 pounds per square inch. No crushing of the walnut shells was observable, even at these elevated pressures.

Other laboratory tests were conducted to determine the effect of sand erosion on the consolidated walnut shell networks. Oil, containing fine sand (capable of penetrating a 325 mesh screen) was pumped through consolidated walnut shell cores. Sufficient oil was pumped through to simulate a production rate of 200 barrels of oil per day from a 10-foot pay section, over a period of four years. At the conclusion of this accelerated test, the erosive effect of the sand was found to be negligible.

Further laboratory tests were made to determine how successfully a consolidated walnut shell network would hold back various sizes of sand. In this case, the test core was composed of 20-30 mesh walnut shells, consolidated with plastic. The tests indicated that such a network would prevent the production of sand grains, large enough to be retained on a 140 mesh standard sieve. Smaller particles, having a mesh size between 140 to 325, were initially produced through the network until sufficient bridging had occurred to stop the production of sand. At the conclusion of this test, the residual permeability remaining in the core was 4 to 10 Darcys, in com-

he's sure of the right answer...



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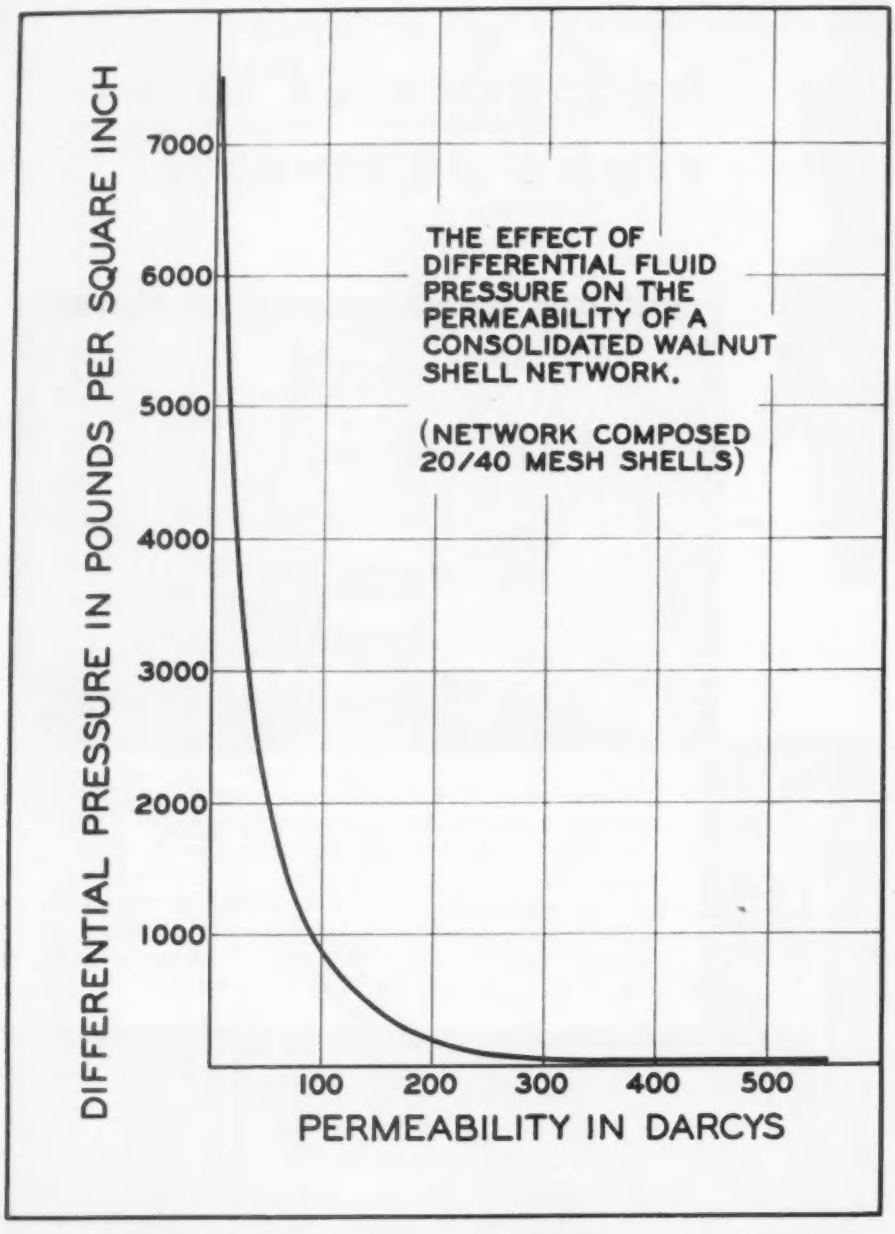


FIGURE 1—Even at elevated pressures, plastic-coated walnut shells remain permeable, a necessary quality for a good sand control agent.

parison to the original 300 to 500 Darcys at the start of the test.

Application. The procedure for conducting a plastic-coated walnut shell treatment is relatively simple. A thorough study of known well conditions, and past well history is essential. Although many factors influence results, certain basic information should always be obtained before attempting a treatment.

1. Physical analysis of formation sand grains. This includes the size of the grains and the variation in grain size throughout the pay zone.
2. Subsurface depth and thickness of producing interval.
3. Bottom-hole temperature and pressure.
4. Volume of fluid produced by well; and the water-oil ratio.
5. Mechanical hookup of the well.

As a general rule, treatments are made under a packer or retainer, in order to localize any high pressures which may be encountered. The most satisfactory tool for this type of job is designed to permit circulation of fluid below the tool, through a tail pipe. Prior to the application of the walnut shells, oil is pumped into the well to establish an injection rate and pressure. If the well produces considerable water, an additional volume of oil is injected to flush the water away from the vicinity of the well-bore.

The graded walnut shells are then coated with plastic in a mixing tank, after which they are dispersed in the oil carrying agent. The resulting slurry is pumped through the tubing and into the formation, at sufficient pressure to assure a satisfactory pack-off.

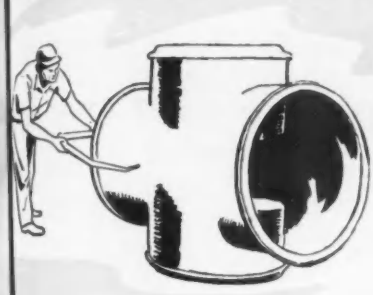
Full coverage of the exposed formation is essential. At present, it is believed that the best method for accomplishing this is to secure two screenouts; however, successful jobs have been obtained using only one stage, and without obtaining a screenout. The fluid over-flush is held to one barrel or less on any one stage, whether or not a screenout is obtained. At the conclusion of the placement of shells, the pressure is allowed to bleed off slowly until static conditions are reached. In areas where large volumes are required the initial fill-up can be made with sand followed by the plastic-coated walnut shells. At the conclusion of the treatment, the well is shut in to allow the plastic to harden. The amount of time required will vary, depending upon bottom hole temperature conditions. In most cases, the setting of the plastic can be controlled so that the shut-in time will be 24 hours or less.

Field Results. The first sand control treatments using plastic-coated walnut shells were performed in the Bully Camp field. Ten wells were treated in this initial development program. Four of these 10 wells were upper sections of dual completions.

This development program was undertaken in order to exploit dual completion possibilities which otherwise could not be effectively sand controlled. These wells were producing from Miocene sands and ranged from new completions to wells several years old. The pay thickness varied from 8 to 36 feet and they were completed with pipe, set through and perforated. The wells were treated with 20-30 mesh walnut shells, in two or more stages. Full opening, retainer-type packers, with sufficient tail pipe to reach through the perforations, were employed. In each instance mud was the fluid used to hold the well. The general rule after treatment is for the wells to make an initial slug of sand upon clean-up, and then produce sand-free.

Table 2 is a summary of the results obtained in this initial development program.

This development program of 10 wells was completed without a single



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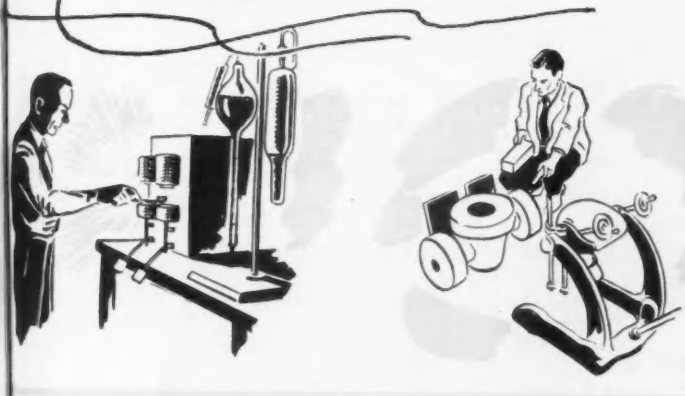

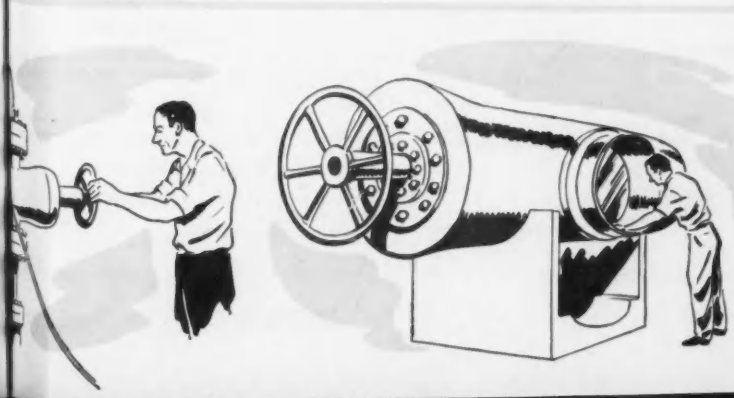

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failure. All of these wells in seven separate reservoirs, were successfully controlled. It is of interest to note that bottom hole pressures could be taken in this field, previously impossible due to sand bridges encountered in the tubing. Also of interest is the fact that the wells have not sanded up when they have been shut in, which was prevalent in the past. At the present time, all of these wells are making either their top allowable or very close to it.

Sand control treatments using plastic-coated walnut shells, which have been made in other oil producing areas, are summarized in Table 3.

ACKNOWLEDGMENT

This was prsented as a paper at the Fall meeting, AIME Petroleum Branch, New Orleans, Oct. 2-5, 1955, and has been released for publication in WORLD OIL by AIME and Dowell Incorporated, Tulsa.

TABLE 2
Results of Sand Control Treatments in the Bully Camp Field

Well	Treatment	Producing	Walnut Shells	Maximum	Before Treatment		After Treatment
A	12-30-54	6468′-6480′	713 lbs. 2 stages 1.2 cu. ft./ft.	6220 psi	I.P. 165 BOPD on 9/64″ @ 800 psi Sanded up four times in previous year	1- 2-55 1- 3-55 3- 8-55 5-25-55	144 BOPD on 9/64″ @ 650 psi 201 BOPD on 13/64″ @ 525 psi Test for Stability. Tool run to bottom—No sand Tool run to bottom—No sand Producing top allowable.
B	1-28-55	4940′-4976′ Dual (Tubing well)	4050 lbs. 4 stages 2.25 cu. ft./ft.	5960 psi	I.P. 177 BOPD on 9/64″ @ 800 psi Well sanded up in two months	2- 2-55 3- 8-55 5-25-55	171 BOPD on 9/64″ @ 640 psi Made considerable sand on clean-up Prod. top allowable-sand bridge found @ 3382′. Top allowable. No sand produced 3 bridges found. Fine grained sand.
C	1-28-55	4796′-4804′ (Casing well)	3600 lbs. 4 stages 9 cu. ft./ft.	6130 psi	I.P. 82 BOPD on 5/64″ @ 340 psi Sanded up.	2- 2-55 5-25-55	117 BOPD on 9/64″ @ 375 psi. No sand. Top allowable—no sand
D	2- 8-55	6520′-6530′ Dual (Tubing well)	560 lbs. 2 stages 1.12 cu. ft./ft.	6500 psi	Sanded up on completion	2-13-55 3- 8-55 5-24-55	136 BOPD on 9/64″ @ 640 psi. No sand. Top allowable. No sand @ 1040 psi. Bailer found small bridge @ 6504′. Top allowable. No sand. Bailer found bridge @ 6525′
E	2- 8-55	6050′-6060′ Dual (Casing well)	546 lbs. 2 stages 1.1 cu. ft./ft.	6420 psi	124 BOPD on 9/64″ @ 780 psi	2-13-55 5-24-55	144 BOPD on 9/64″ @ 840 psi. No sand. Top allowable. No sand.
F	3-12-55	4836′-4854′ Dual (Casing well)	1133 lbs. 3 stages 1.25 cu. ft./ft.	5000 psi	New well	3-15-55 4-21-55	141 BOPD on 9/64″ @ 440 psi. No sand. 165 BOPD on 9/64″ @ 500 psi. No sand.
G	3-25-55	6052′-6088′	921 lbs. 2 stages 0.51 cu. ft./ft.	6580 psi	New completion	3-28-55 4-19-55	150 BOPD on 9/64″ @ 900 psi. 105 BOPD on 9/64″ @ 900 psi.
H	4- 1-55	7914′-7934′	2460 lbs. 3 stages 2.4 cu. ft./ft.	7200 psi	330 BOPD on 9/64″ @ 1600 psi. Two months later 44 BFPD w/20% brine. Sanded up. Squeezed and again sanded up.	4- 5-55 5-25-55	Plug was not drilled out of casing 191 BFPD. 50% brine, No sand. Bailer found no sand.
I	4-28-55	4920′-4950′ Dual (Tubing well)	668 lbs. 2 stages 0.45 cu. ft./ft.	5800 psi	New well	5- 1-55	Top allowable. 155 BOPD on 9/64″ @ 650 psi.
J	4-28-55	4720′-4737′ Dual (Casing well)	1000 lbs. 2 stages 0.7 cu. ft./ft.	6700 psi	New well	2-25-55 5- 1-55	Tools run to bottom. No sand. 155 BOPD on 9/64″ @ 510 psi.

TABLE 3
Results of Sand Control Treatments

Well	Treatment Date	Field	Producing Interval	Walnut Shells Used	Maximum BHP	Before Treatment		After Treatment
K	2-24-55	Erath	8669′-8681′	1400 lbs. 3 stages 2.4 cu. ft./ft.	10300 psi	New well. Sanding up badly		173 BOPD 19/64″ @ 1375 psi. Sand-free at surface. Small bridges found in tubing. Production not impaired.
L	4- 5-55	Delta Farms	9403′-9412′	970 lbs. 2 stages 2.15 cu. ft./ft.	9100 psi	1945 284 BOPD on 9/64″ @ 1560 psi 1952-1955— 8 workovers to get back on production. Last year produced 5 days.	5-25-55	Slow coming in. Acidized and produced 800-900 BWPD (Gas Lift). 212 BOPD. 1800 BWPD (Flowing). No sand.
M	4-12-55	West Lockport	5292′-5294′	1600 lbs. 2 stages 16 cu. ft./ft.	6830 psi	Sanded up on D.S.T.	6- 1-55	Slow coming in. Acidized and brought in brine. Well squeezed and re-perforated twice. Came in clean. 82 BOPD @ 1250 psi. No sand.
N	4-21-55	North Cankton	3947′-3956′	1300 lbs. 3 stages 1.4 cu. ft./ft.	3900 psi	New well. Bad sand problem.	4-27-55 4-28-55 5- 5-55 5- 9-55 5-12-55 5-16-55 6- 2-55	Gas Lift. 36 BFPD 4% sand 60% water. Making up to 20% sand. Tubing pressure up. 350 BFPD 10% oil. 5% sand. Making sand. Flow 35 BOPD 84 BWPD @ 1180 psi. No sand. Gas Lift. 30 BOPD. 300 BWPD. Some sand. Flow 180 BFPD. 10% oil. Trace of sand.
O	5-16-55	Hackberry	6587′-6602′	2000 lbs. 3 stages 2.65 cu. ft./ft.	6000 psi	2 BOPD before sanding up.	6- 1-55	Large chunks of cement were reversed from well after each stage. Split pipe feared, so network was not drilled out after final stage. 7 BOPD on gas lift. No sand.
P	5-10-55	Little Bayou	2216′-2234′	1371 lbs. 3 stages 1.5 cu. ft./ft.	2300 psi	Sanded up on D.S.T.	5-13-55 5-18-55	85 BOPD on 19/64″ @ 55 psi. No sand. Only flowing well in this formation. 60 BOPD on 9/64″ @ 100 psi. No sand.
Q	5-31-55	Evangeline	6798′-6804′	1900 lbs. Sand 800 lbs. shells 1 stage 2.6 cu. ft./ft.	6800 psi	33 BOPD pumping before sanding up.		Only 1 stage, due to pressure limitation. 130 BOPD on pump. Sand-free.

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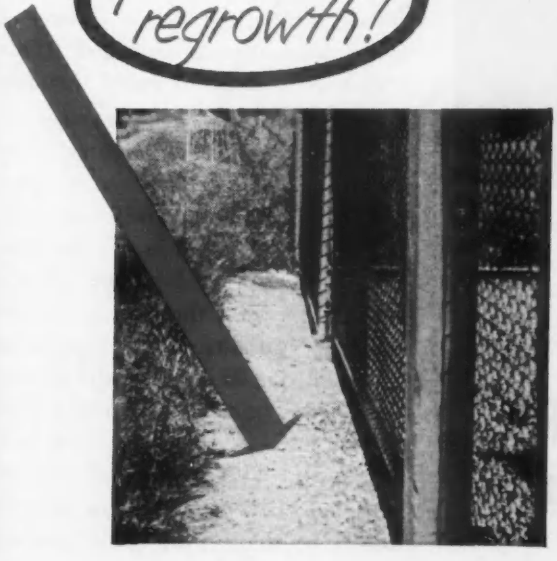

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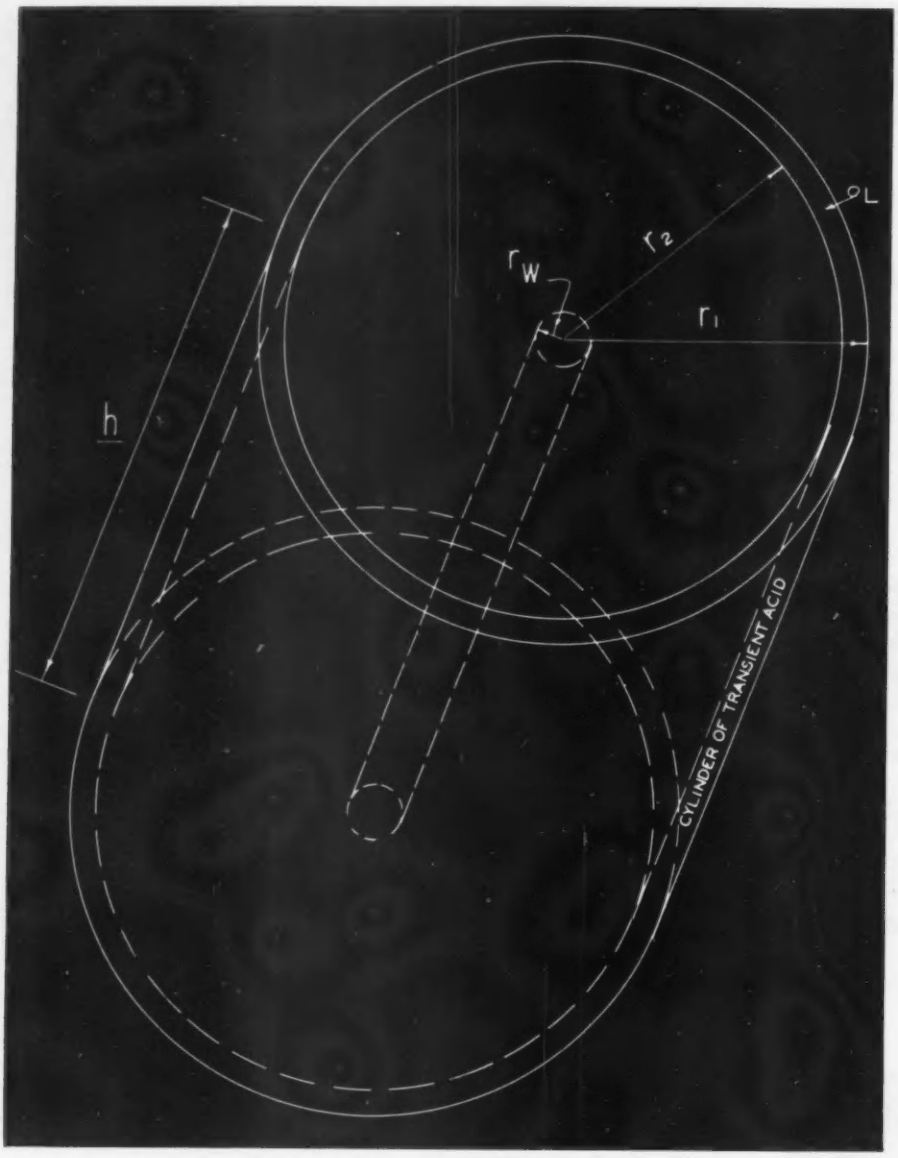


FIGURE 1—For use in calculating transient history solution through the formation.

Acid-Soluble Cement Helps Injection Well Completions

What happens when acid-soluble cement, perforating and acidizing are combined in cased-through injection well completions?

- **Injection interval controlled.**
- **Thief zones bypassed.**
- **Injection rates increased**

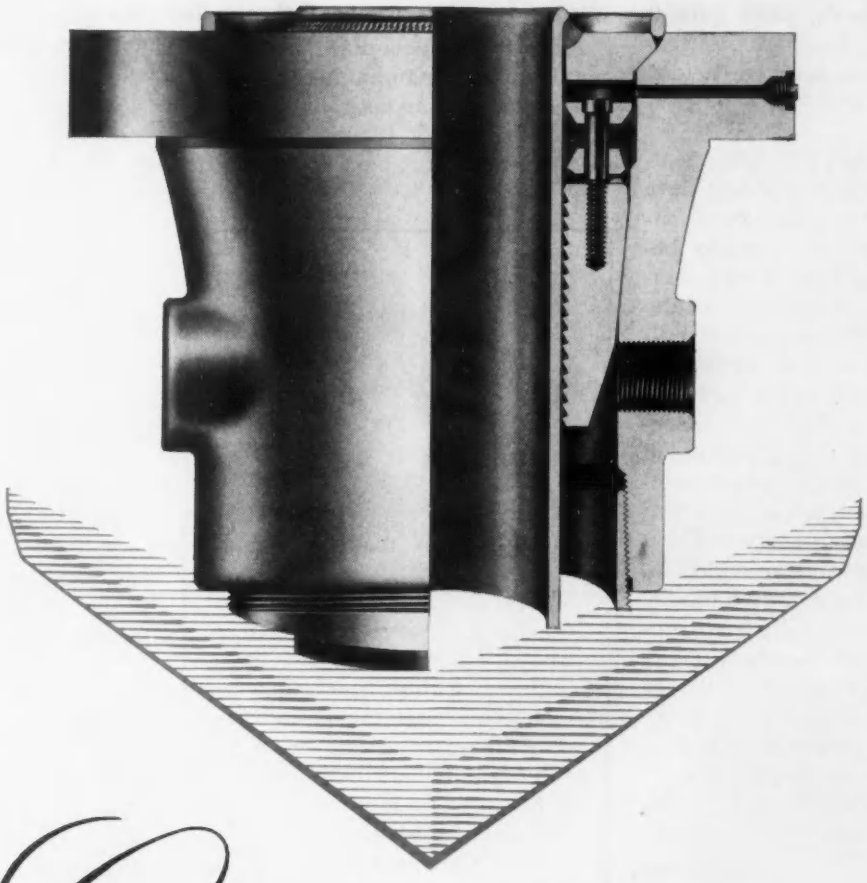
By BERT MURPHY
F. Kirk Johnson Company,
For Worth, Texas

WHERE THE CASED-THROUGH and perforated injection well is desirable due to reservoir characteristics, the use of acid soluble cement can result in completion effectiveness approaching the open-hole type. In most cases, good practice would dictate that in all types of completions acid soluble cement should be spotted against formation intervals that have even remote possibilities of being floodable This practice, for example, will permit easy access to the "gas" sand that was found to contain floodable quantities of oil and had been placed behind pipe in an open hole completion.

Cased through and perforated injection well completions are often desirable in secondary recovery projects where careful control of the injection interval is necessary. This type of completion permits close selection of the input interval. It also avoids bypassing through thief-zones and allows troublesome zones to be shut off by squeeze cementing. Better control of caving formation is obtained if the productive interval is cased through.

In areas of low-pressure reservoir and low-capacity formations, however, this method has been avoided due to relatively low injection rates experienced. To eliminate this difficulty, and take advantage of the benefits of casing through, a method of using gun-perforating equipment and small quantities of acid has been developed. The method provides good injectivities by cementing the perforated zone with acid soluble cement.

Briefly, this completion method consists of adding 40 to 50 percent finely ground white limestone (calcium carbonate) to the regular cement used against the formation. The well is then selectively perforated based on core or log data and the zone acidized. Acidizing the perforations may be done in a number of ways. One method that has been successful is to interrupt injection into the well and place a small quantity of acid in the casing. Injection is then resumed. This may be repeated until optimum



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injectivity is achieved. In the case of complex permeability variation or thief-zone problems, selective acidizing may be warranted.

Technical Aspects. Numerous articles concerned with perforating have shown the productivity (and thus conversely, injectivity) relationship between open-hole and perforated completions is due to the geometry of the system involved. These studies indicate that above a certain perforation density (number of holes per foot times perforation radius) the productivity capacity of cased, perforated wells compared with that of completely penetrated uncased wells (Q/Q_o) will approach or exceed, 1.0, due only to geometric considerations. Since the perforation density is usually of a value to theoretically give productivity ratios and therefore injectivity ratios in the range of 0.8 to 1.0 + then other factors must be responsible for the poor results in perforated injection well completions.

It is believed that the three principal damaging factors involved are:

1. Perforation plugging resulting from mud particles being driven into the perforation.
2. Perforation plugging resulting from cement particles being driven into the perforation.
3. Reduction in effective well-bore permeability caused by the crushing of sand grains.

These damaging factors can be circumvented or minimized by:

1. Removing mud particles and cleaning well bore and formation prior to running casing.
2. Removing cement particles from the perforation.
3. Opening uncrushed sand to injection.

Item 1 is tried in most well completions and one satisfactory method is discussed under Case History. Items 2 and 3 can be achieved if a method of dissolving cement is used.

Regular 15 percent hydrochloric acid only partially dissolves portland cement. This is due to the rapid formation of protective siliceous gel on the surface of the cement preventing continuous action by the acid. The cement is readily dissolved, however, if sufficient calcium carbonate is added to form a soluble web. This web destroys the gel and after about 10 minutes contact with the acid only a silty residue of the cement remains.

Experiments show that up to 3 percent bentonitic material may be added to cement without noticably influencing the solubility brought about by calcium carbonate. No adverse efforts have been noted in the field as a result of the addition of calcium chloride to acid-soluble cement to hasten setting time. Thus, the product formed by mixing calcium carbonate and cement can be used in the usual way in well-cementing operations.

The acid soluble cement is made by mixing finely ground limestone or limestone dust with regular portland cement in the approximate ratio of 2 to 3. The limestone may be added to cement in the mixing tank or dry mixed in the hopper automatically.

Although this mixture does not have the strength of regular cement, it is believed to be ample for a vast majority of the shallow fields being water-flooded. This is especially true if the acid-soluble cement is spotted opposite the pay while the remainder of the cement column is composed of regular cement.

If relatively low injectivities are experienced after perforating, small quantities of acid may be injected through the perforations to remove the acid-soluble cement and expose the uncrushed sand.

A simple, inexpensive method is used to acidize most injection wells. Briefly the method consists of allowing the fluid level in the well to fall off, pouring the acid through the wellhead into the casing and resuming the injection. Where well pressure prohibits this method a small, portable pressure volume tank may be used for acid injection. If a bypass is located near the wellhead the acid may be injected without shutting the well in. By connecting the tank into the injection line and using plant pressure the acid may be forced from the tank into the well.

Experiments show that a 15 percent hydrochloric acid solution dissolves approximately 1.5 pounds or 16 cubic inches of calcium carbonate per gallon. When completely neutralized the solution is about 70 percent saturated. The danger of nullifying the selective feature of gun perforated completions by dissolving the cement sheath into a thief-zone is minute. The radius around the perforation that will be dissolved is a square-root function of the quantity of acid through-put.

Thus, while a gallon of acid will dissolve a cylinder 1-inch thick and 2.5 inches in radius, a barrel will only dissolve a cylinder 1-inch thick and 15-inches in radius.

Since the usual treatment is 1 to 3 barrels through numerous perforations the remoteness of the possibility is apparent. Additional control is given if injectivity profile logs are run. Selective acidizing may then be used to correct injectivity anomalies indicated by the log.

It is not believed that reprecipitation of the dissolved calcium carbonate around the well bore will affect the completion to any appreciable extent in a majority of waters being injected in southwestern water-floods.

The chemical effect of acid on injected water and the subsequent effect on the formation may be determined if it is felt pertinent. This can be done by determining the chemical nature of the water with various concentrations

About the Author

BERT MURPHY is a Texas registered professional engineer with a B.S. degree in petroleum engineering from Stanford University and has done graduate work in reservoir engineering and evaluation at the University of Southern California. In 1948 and 1949 he worked with Continental Oil Company and in 1950 joined Signal Oil and Gas Company where he advanced to project engineer and supervisor of a West Texas flood project. In 1954 he was engaged as chief engineer by F. Kirk Johnson and was made assistant manager of their Water-flood division just prior to the incorporation of the firm which became Ambassador Oil Corporation.

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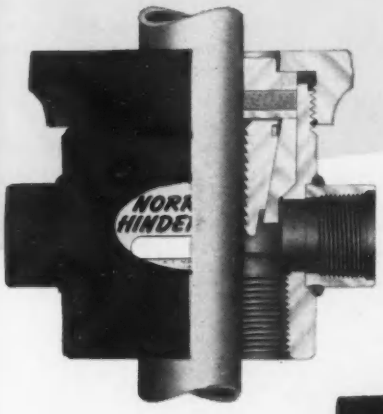

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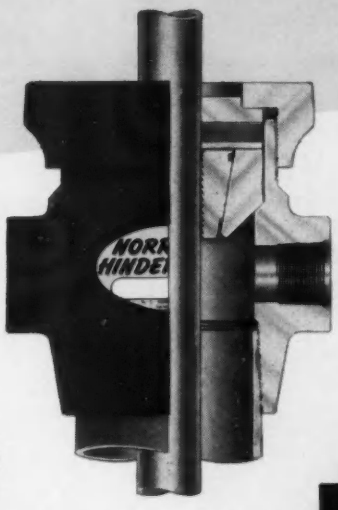

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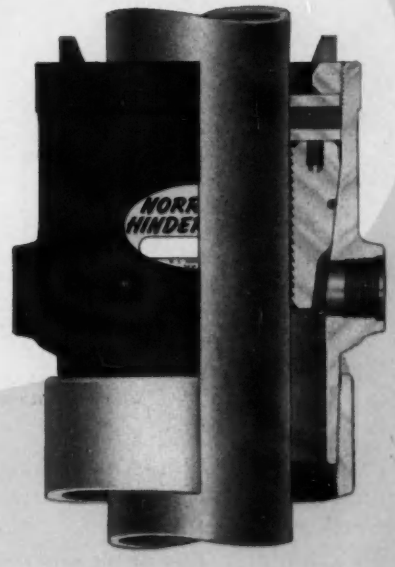

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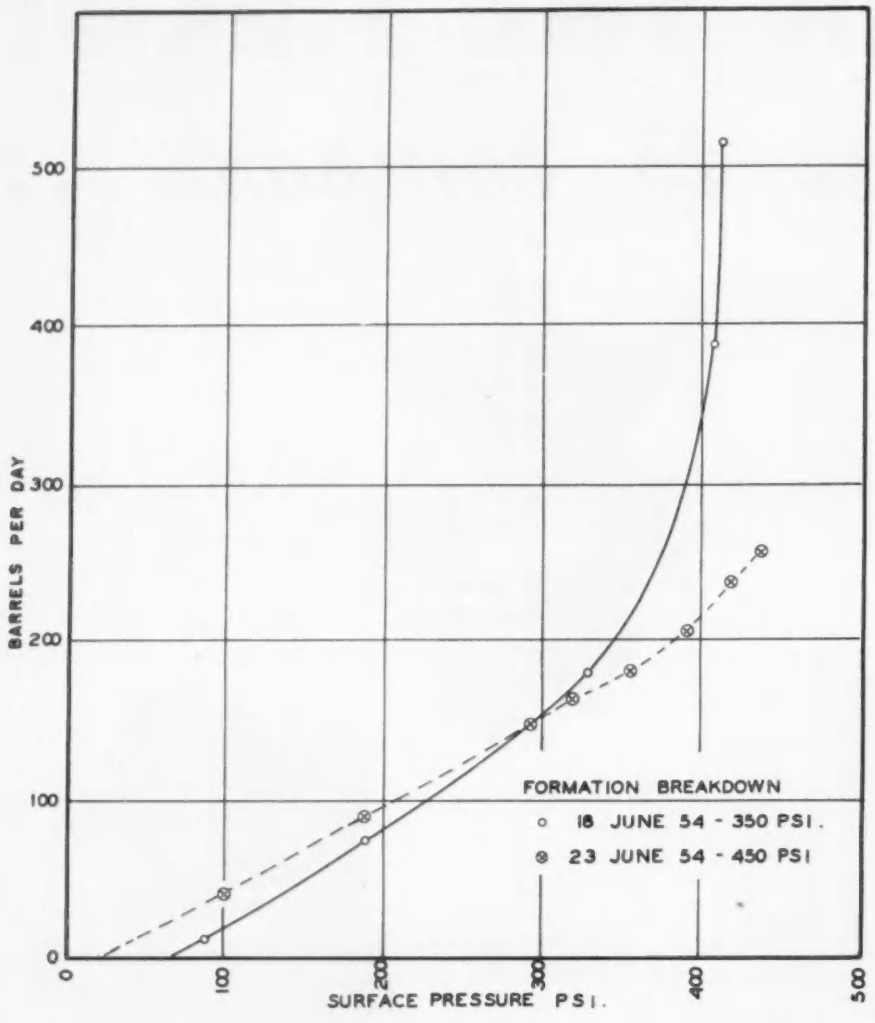

FIGURE 2—Formation breakdown pressures on acidized test well increases as formation becomes saturated around well bore.

of acid and predicting where these concentrations will occur away from the well bore.

The chemical nature of the mixtures can be found by analyzing various concentrations of neutralized or partly neutralized acid and the subject water. Using the methods of Stiff and Davis and others, the stability of these mixtures for many dissolved solids can be calculated. A further refinement of this would be scaled experiments. These could determine what effect time, heat, pressure, and the area of contact with the acid-soluble cement would have on neutralizing the acid.

It may be assumed that the acid is diluted by the immobile percent of the formation water as it advances through the formation. In this case, a prediction of the percentage mixtures of acid and water moving through the formation may be made. (This should be maximum dilution in a sand composed only of silica.) Dilution will then follow the law of constant percent decline i.e.:

$$P = dP/d\overline{V}$$

where P = percent of regular acid in the volume moving through the reservoir equal to volume injected.

$\overline{V}$ = Volume of immobile formation water passed through by volume injected, divided by volume injected.

$$\ln P = K\overline{V}$$

$$P = eK\overline{V} = 10^{a\overline{V}} \text{ where } a = K/2.3$$

If it is assumed 0.50 dilution occurs each time the volume injected passes through an equal volume of immobile formation water, then

$$0.50 = 10^{a}$$

$$a = (0.699\text{-}1) \qquad (1)$$

$$\text{so that } P = {}_{10}(0.699\text{-}1)\overline{V}$$

The transient history of the volume moving through the formation may be calculated. (Figure 1.)

$$V_o = V_1 - V_2$$

where: V_o = Volume of the formation occupied by the transient acid.

V_1 = Total volume of formation to outer perimeter of transient acid.

V_2 = Total volume of formation to inner perimeter of transient acid.

$$V = p\,(1 - S)\,V_o$$

where V = volume of acid injected.

p = porosity.

S = fraction of pore space occupied by immobile water.

(1-S) = fraction porosity occupied by transient acid.

$$\text{also } \overline{V} = (S/1 - S)\ (V_1/V_o)$$

If it is assumed that the formation is homogeneous,

$$\text{then: } V_1 = \pi h r_1^2$$

$$V_2 = \pi h r_2^2$$

$$V_o = \pi h (r_1^2 - r_2^2)$$

$$L = r_1 - r_2$$

$$L = \frac{Vo}{\pi h (r_1 + r_2)}$$

$$r_2 = r_1 - L$$

$$r_1 = \frac{\left(\frac{Vo}{\pi hL}\right) + L}{2}$$

$$\overline{V} = \frac{[(S/1 - S)r_1^2]}{(2r_1L - L^2)} \qquad (2)$$

Using equations 1 and 2 it is possible to predict approximately where the acid-water-cement combination tested will occur in the formation. Brief tests and study indicate that precipitation of the dissolved calcium carbonate and cement, if it should occur at all, will be distant from the well bore. Distributed through such a relatively large volume of formation it will have no discernable adverse effect on injectivity.

Case History. Well A located in a low-capacity, low-pressure formation in the Permian Basin was drilled with a 7-inch hole to 1941 feet, using cable tools. The interval from 1856 to 1934.7 feet was chip-cored by 1- to 2-foot bit runs, with a maximum of 5 to 10 gallons of water in the hole. Four barrels of mud acid were then placed in the productive interval and allowed to stand 30 minutes. The well was then bailed to clean the hole and recover the acid. The pH of the fluid in the first bailer run was 0.5. Cycles of 4 barrels of brine were repeatedly added and bailed dry. The pH returned to 7.0 ± after 11 such cycles.

The well was gamma ray, neutron, and caliper logged; 5½-inch casing was cemented at 1940 feet with 42 sacks of construction cement treated with 4 percent bentonite. Sixteen of these sacks were composed of 60 percent construction cement and 40 per-

One piston tubing anchor keeps tubing in hole longer—cuts well pulling costs

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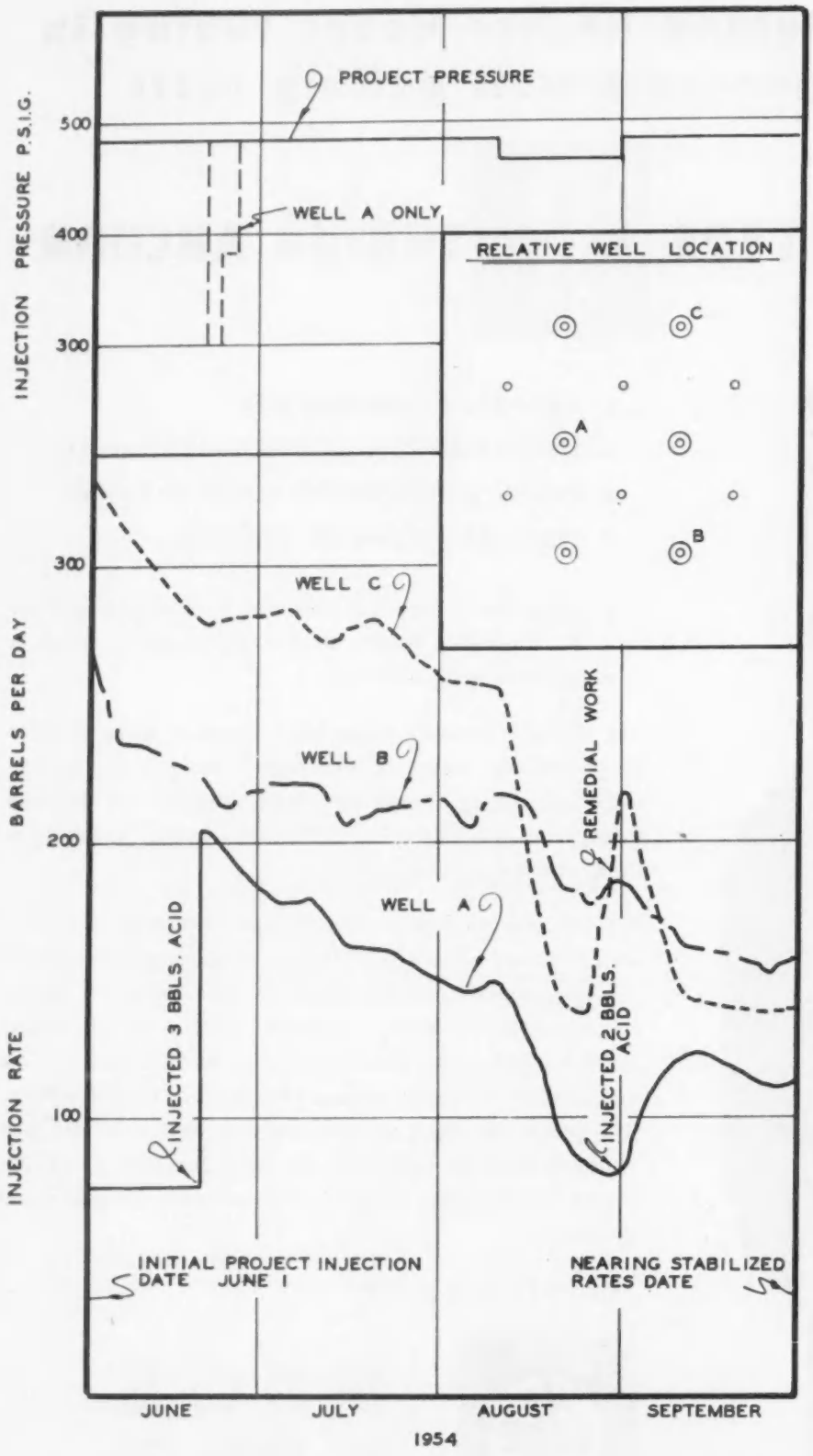

FIGURE 3—Injection rates for wells tested shows cased-through and perforated well stabilized rate is about 80% of open hole wells at equal pressure.

cent finely ground limestone. These were spotted in the cement column so that acid-soluble cement straddled all productive intervals. The well was then left in a standby condition, pending completion of injection facilities.

When injection facilities were complete, the casing opposite the pay intervals was perforated with ½-inch bullets, 4 per foot, with the casing full of filtered, treated brine. The well was then acidized, by the method previously described, with 3 barrels of acid, and began taking quantities of water at 450 pounds per square inch gage. Final rate and pressure was 465 barrels per day at 150 psig. The well was shut in for 33 days until continuous project injection was begun. When checked later the well took 76 barrels per day at 500 psig.

Seventeen days later the well was again acidized with 3 barrels of acid. Pressure-rate curves were made for Well A and the surrounding injection wells. A study of these curves shows that formation breakdown pressure for the gun-perforated well was 330+ psig, and 500+ psig for the other injection wells. Well A was pinched back to 300 psig and pressure-rate curves were taken at intervals of one day until the breakdown pressure rose to 450 psig, when the well was opened to system pressure (Figure 2). It is presumed that the breakdown pressure rose as saturation around the well bore increased.

The injection rates of Well A and offset injection wells are shown in Figure 3. This flood is being kept in balance by constant-pressure method, i.e. the wells are allowed to take what water they will at a uniform well head pressure determined by field tests to be 20 to 50 psi below the formation breakdown pressure. Wells B and C were drilled with cable tools and completed in much the same way as Well A, except that they were completed open hole. The reservoir has fairly uniform characteristics in the section of the field occupied by the three subject wells. It should be noted that the stabilized injection was approximately 80 percent of the rate for Wells B and C. This is about as predicted due to the geometric consideration of the completion methods.

ACKNOWLEDGMENT

This article, prepared for WORLD OIL, is based on material presented at the spring meeting, meeting, Southwestern District, Division of Production, American Petroleum Institute, at New Orleans, March, 1955.

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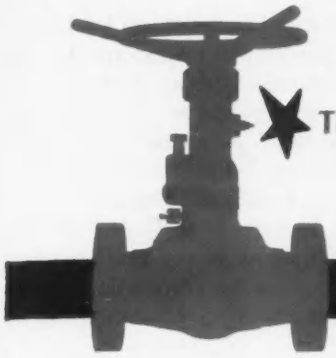

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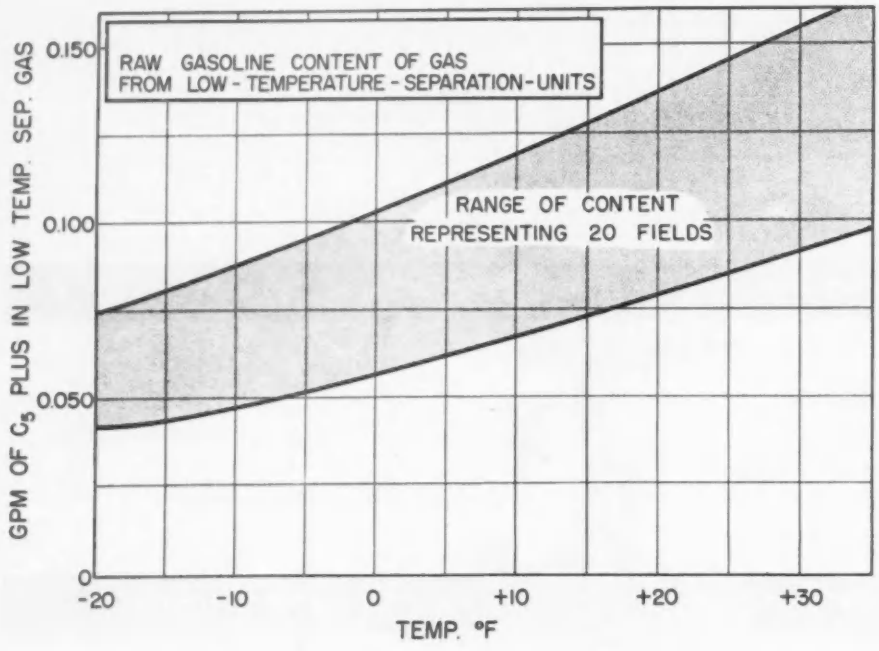


FIGURE 1—Stable liquid recoverable by adsorption.

New Wellhead Adsorption Unit and What It Means

An important contribution to gas production which can . . .

- **Reduce internal pipe corrosion.**
- **Reduce hydrate difficulties.**
- **Reduce operating costs.**

By A. S. PARKS, United Gas Corporation, Houston
and **W. M. DOW,** United Gas Corporation, Shreveport.

EXTENSIVE LABORATORY research and field testing have resulted in the development of a new, small, short-cycle, dry-desiccant adsorption unit for gas wellhead applications. A fully automatic, self-contained and skid-mounted unit may be used to dehydrate the gas stream or to extract additional hydrocarbon fractions as well as dehydrate the gas. No external source of energy, other than the gas stream which is to be dehydrated, nor external cooling medium, such as water or gas, is needed.

The development program as initiated was directed to the problem of dehydration of natural gas at the wellhead. As the work progressed, the importance and possibility of additional hydrocarbon recovery from the gas stream became evident. Dehydrating gas for sales purposes is obligatory; the prospect of doing this at a profit from additional liquid recovery is attractive. A hydrocarbon adsorption unit can recover from 2 to 4 barrels more of condensate per million cubic feet of gas than can conventional wellhead separators.

Here's the problem. Wherever natural gas is produced, some water will be produced. Such water usually enters the well bore in the vapor phase, and partially condenses as the gas moves up the flow string to the surface. At the wellhead, there is usually water present in the well stream in both vapor and liquid phases.

Vapor-phase water in low-enough concentrations is relatively harmless in a natural-gas gathering and transporting system. It is the liquid-phase water which causes all of the difficulties experienced. The usual trouble caused by liquid water is the formation of gas hydrates; everyone is familiar with the so-called freezing of gas lines and equipment in cold weather. Another trouble which is somewhat more obscure than hydrate formation is internal corrosion of the pipe. Elimination of liquid water from a gas-handling system effectively prevents the formation of hydrates and corrosion.

To prevent hydrate formation and internal-corrosion attack, most gas-purchase contracts specify a maximum water content; usually 7 pounds per million cubic feet of gas, but in some cases it may be 6 or even 5 pounds. Likewise, the quantity of condensible hydrocarbon liquids allowed in the gas is limited in some contracts. This is ordinarily some 200 gallons per million cubic feet of gas, as determined by the standard NGAA charcoal test. Some of the gas-purchasing companies pay a premium for dehydrated gas over wet gas as produced through conventional equipment.

It has become increasingly urgent in recent years to remove water and hydrocarbon liquids from natural gas by means other than the large central plant that is commonly used. Transportation of the gas from the wellhead to the plant is a problem. The lines in the gathering system freeze

during cold weather, and corrosion in such lines is known to be progressing at an alarming rate. If water were removed from the system at the wellhead, such corrosion and freezing would be prevented; so a program to develop a practical means for such water removal was started several years ago.

LIMITATIONS OF CONVENTIONAL METHODS

Simple Heater and Separator. This wellhead production process is basic and is the conventional production assembly on most natural-gas wells. The gas stream from the well is heated in order that the pressure may be reduced to that in the separator without the formation of hydrates. The temperature of hydrate formation is the limiting condition of such a system.

Gas from the separator of such a system is saturated with water and hydrocarbons at the temperature and pressure of the separator, and any further reduction in temperature will result in the condensation of liquids, both water and hydrocarbon, in the pipe line. Considering the example of a separator operating at 1000-pound pressure, the lower limit of temperature at which it may operate is something of the order of 70° F. The produced gas will contain 25 pounds of water vapor per million cubic feet, and the liquefiable hydrocarbon content will range up to 400 gallons per million cubic feet. Such gas cannot meet pipe line requirements.

Low-temperature Separation Units. By removing liquid water from a high-pressure gas stream before dropping the pressure into a separator and by providing heating coils in the separator to melt hydrates, relatively low temperatures of separation may be achieved. Considerable water vapor and additional hydrocarbons are thus condensed, so the gas produced through a low-temperature system has a lower water and condensible hydrocarbon content than that produced through a conventional separator.

When pressure conditions at the wellhead are high, sufficient pressure drop is available to permit cooling to the degree that dehydration to pipe line specification is accomplished. Later in the productive life of the well when pressures are lower, sufficient pressure drop is not available to produce pipe line specification gas. At this time additional equipment must be installed to enable dehydrated gas to be produced.

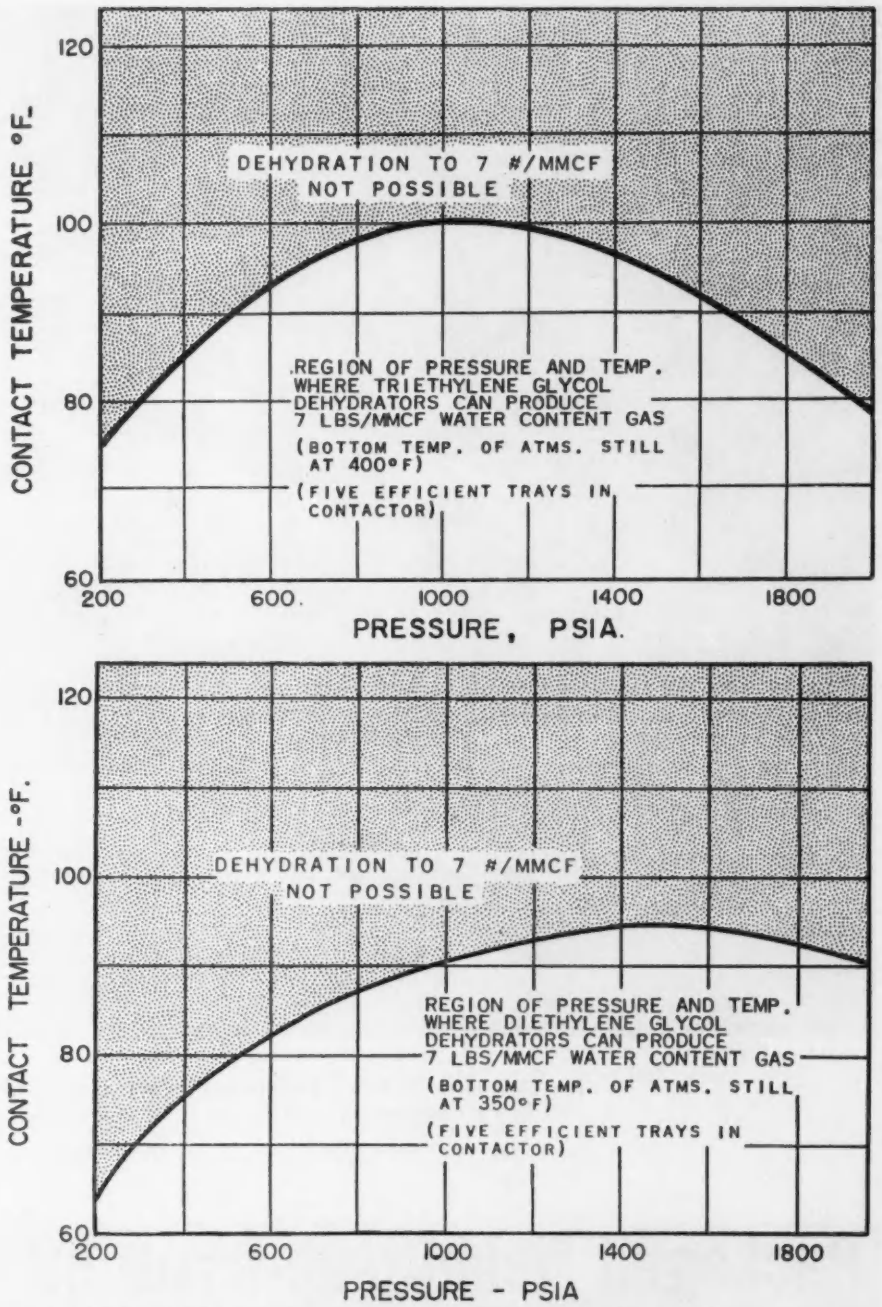
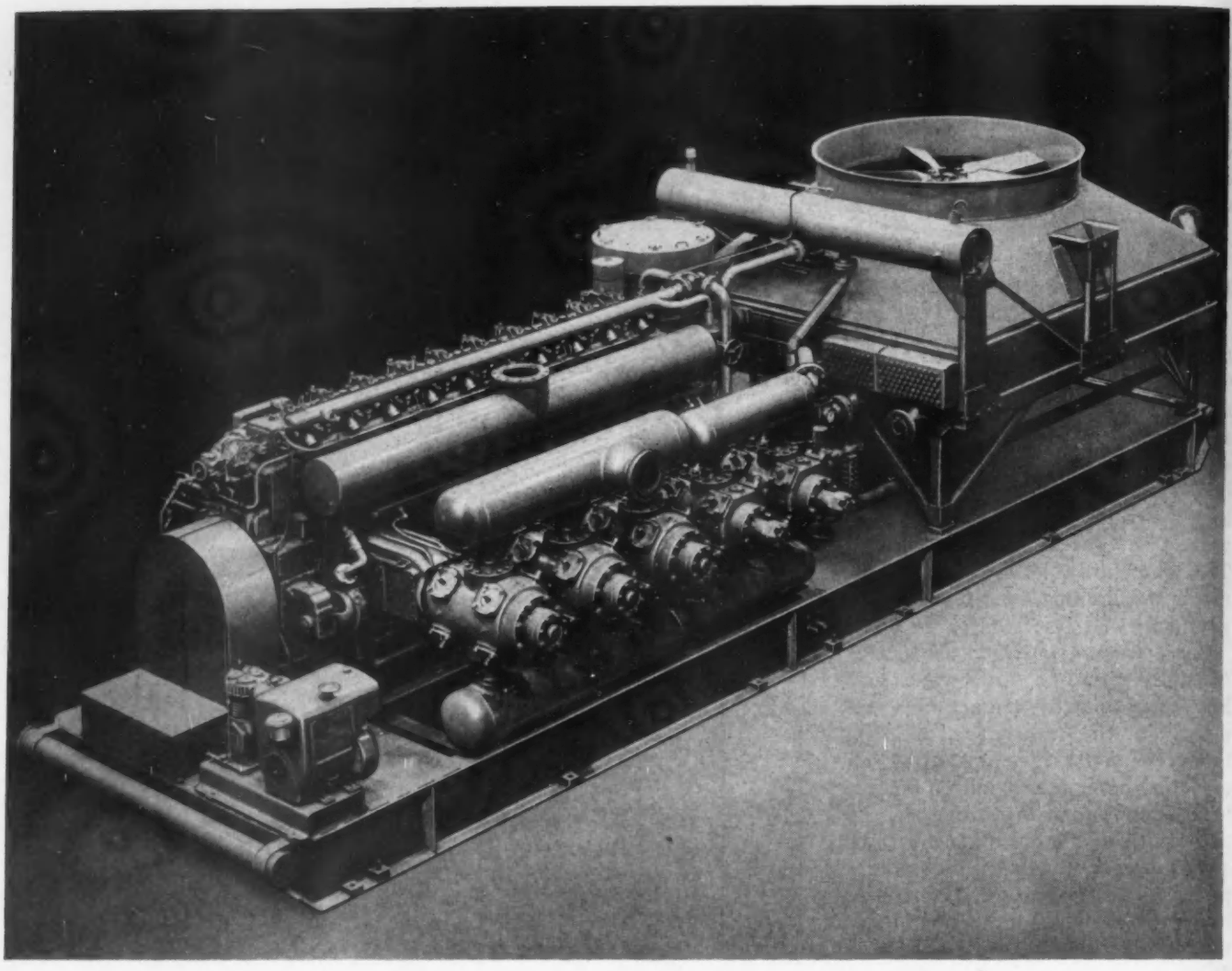


FIGURE 2—Limitations of pressure and temperature for efficient operation of glycol dehydration units.

One of the advantages of a low-temperature separation system at the wellhead is that additional hydrocarbon-liquid recovery in the stock tank over conventional separation is considerable. This makes low-temperature separation economically attractive. However, studies indicate that the actual removal of liquefiable hydrocarbons from the vapor phase in low-temperature separators is limited, and decreases rapidly as the operating temperature increases. Figure 1 is a plot of tail-gas analyses from low-temperature separation units in 20 fields. The quantity of pentanes plus found to be in the gas after processing by these units represents stable liquid that could be recovered by adsorption.

Thus, the capacity of a low-temperature separator to remove water vapor from gas is limited by the temperature at which it may operate, and this temperature is dependent upon the pressure drop available. Any material that is not condensed from the vapor phase in the separator is carried out by the tail gas, and thus is not re-



The Clark model HMAB is a completely self-contained compressor station. It is built in ten, eight and six cylinder sizes of 550, 440 and 330 BHP respectively.

Packaged Field Compressor Introduced by Clark

New "Midget Angle" develops 25% more power

A 25% more powerful "packaged" compressor station for field use has been introduced by Clark Bros. Co., Olean, N. Y.

According to Clark Engineers, the new Midget Angle is a huskier, heavier built unit in all respects than its famed predecessor.

The increased power is developed as the result of greater displacement and a redesign of the combustion chamber and power cylinder porting.

Retains Balanced/Opposed Principal

The new model HMAB incorporates the patented Balanced/Opposed principal of the original Midget Angle. This design results in vibration-free operation. Installation can be readily made on piles, barges, trailers or poor load-bearing soil without costly preparation.

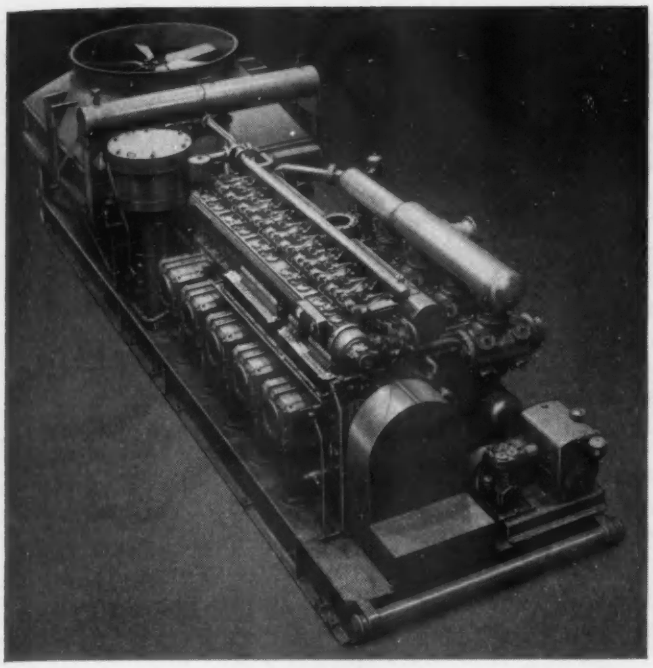
Heavy Compressor Design

The bore and stroke of the new unit has been increased to 8⅜ x 8⅞ inches. To handle the increased power output—power pistons, power cylinder liners, heads, connecting rods and crossheads have been increased in size. Both the upper and lower crankcases have also been increased in size and weight to handle additional horsepower.

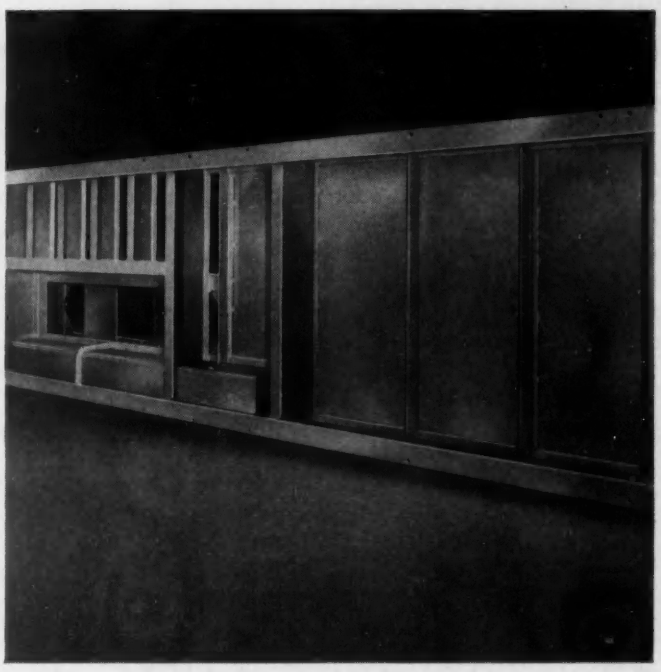
To promote accessibility, the lube oil pump has been mounted on the end of the crankcase—opposite the flywheel end. The water pump is also mounted on the crankcase and is chain driven from the crankshaft. A fully insulated exhaust manifold is used, saving 25% in water cooling load per BHP.

Radiator Designed for Rugged Field Service

The HMAB features an induced vertical air flow radiator design. Wind direction can be disregarded. An exceptionally even flow of air over the entire cooling surface results from the induction principal. Cooling surface is also spread over a large area to permit a close approach to ambient temperature. The finned tubes of each section terminate in common mani-



The packaged unit can be shipped by railroad as a complete unit eliminating costly field assembly.



The extra deep skid or base for the unit is built up from 18" and 20" I beams.

folds, thereby eliminating the need for return bends. Plugs in the manifolds, in line with each tube, permit straight-through visual inspection of the tube inner surface. Tube cleaning, if ever necessary, can be accomplished without removal from the radiator. A unique feature of the Clark radiator is the use of a hydraulic motor to drive the fan. Complicated and often troublesome belt drives are eliminated. Fluid power for the hydraulic motor is furnished by a flywheel driven oil pump. Railroad shipment is possible without removing the radiator from the skid.

Massive Steel Skid

An extra heavy box type skid that is highly resistant to bending or twisting is provided for the packaged units. Main members are 20" I beams. Cross members are 18" I beams and are continuous to assure maximum rigidity. Accessory equipment such as the starting air compressor, interstage scrubbers, air cleaner, surge tank, etc., are engineered into the packaged design. The Clark Midget Angle eliminates costly field erection. Connect fuel and supply lines and it is ready to operate.

Factory Tested Packages

Every HMAB is completely assembled and tested as a unit. With Clark there is never divided responsibility.

Built in Three Sizes

The HMAB will be built in ten, eight and six cylinder models of 550, 440 and 330 BHP respectively. Additional information on the HMAB as well as on the smaller HMA which will continue to be built, is available at any Clark office.

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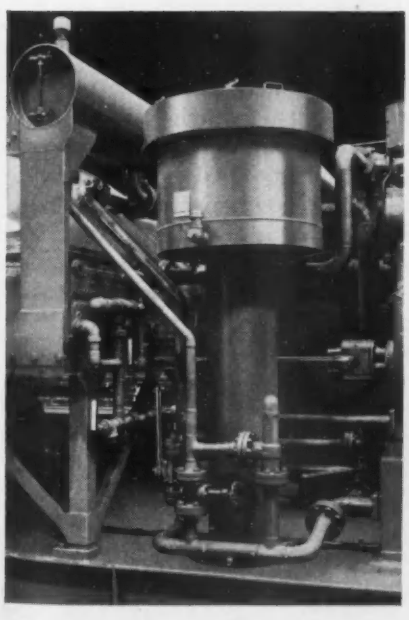
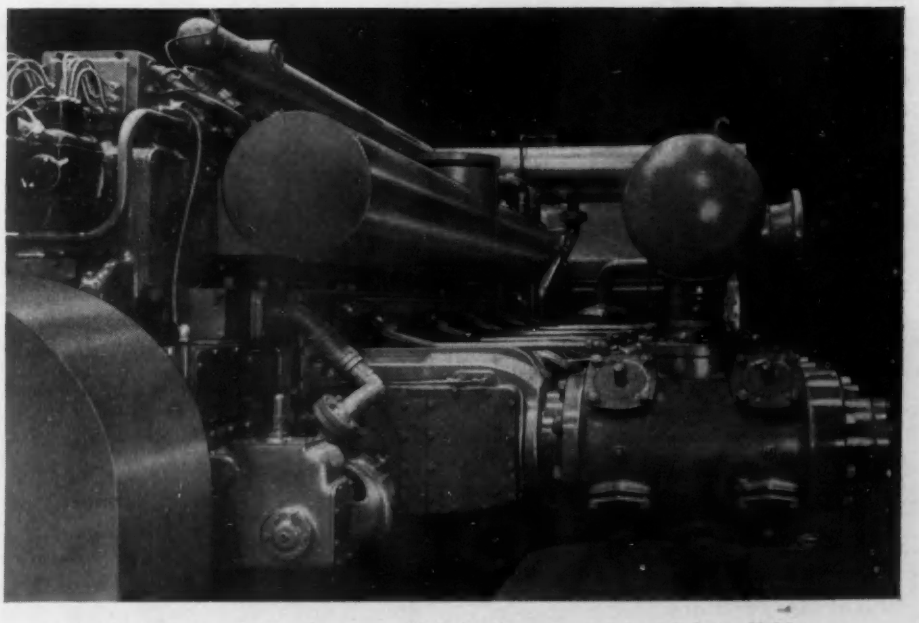


The HMAB has an external oil pump. Air cleaner, scrubbers, etc., are mounted between the compressor and radiator.



Use of a fully insulated exhaust manifold in place of a water cooled manifold saves 25% in cooling duty per BHP. An external chain driven water pump is provided.

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covered. This fact is sometimes not fully appreciated.

Much effort and expense is sometimes entailed in an effort to minimize flash losses in transferring the liquid condensed in a low-temperature separator to the stock tank, usually by the use of stabilizer columns. In most instances, efforts to reduce flash losses from low-temperature separators result in a net gain of a very small amount of additional stable liquid in the stock tank over what would have normally been recovered. In the same installation, more recoverable hydrocarbons might be going down the line in the tail gas than the low-temperature separator was recovering in addition to that possible by a conventional separator.

The losses inherent in low-temperature separation can only increase with declining wellhead pressure. This disadvantage can be partially offset by the use of glycol injection and extensive heat exchange. However, even by these techniques, at least 700 to 1000 pounds per square inch of pressure drop should be available to make the process practical. Losses in uncondensed hydrocarbon fractions in the tail gas are the same in a glycol-injection system as in any other low-temperature separation system operating at the same temperature.

Glycol Dehydrators. Dehydration of natural gas by contacting with glycol may be evaluated from theoretical considerations. Absorption of water vapor by glycol follows definite equilibrium relations, and any other performance of a glycol-water mixture simply cannot happen. On the basis of the processed gas containing not over 7 pounds of water vapor per million cubic feet, the regions of pressure and temperature within which dehydration by glycol contact may be accomplished is set forth in Figure 2.

It is obvious that dehydration of gas by glycol cannot recover any hydrocarbon liquid from the gas stream. Any economic benefit could only be the premium paid for dehydrated gas by a purchaser.

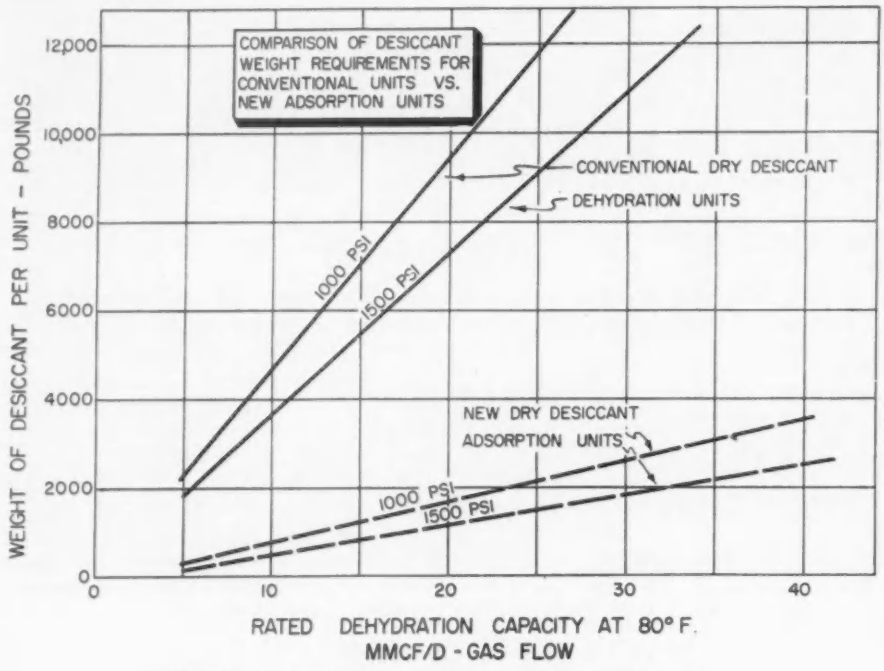

FIGURE 3—Less desiccant required by new adsorption unit.

Conventional Dry-desiccant Dehydrators. Within the range of temperatures and pressures encountered in the production and handling of natural gas, the adsorption of materials from the vapor phase directly on the surface of a desiccant may be accomplished with varying degrees of efficiency. Dry-desiccant dehydration plants are very common throughout the industry, but for practical reasons are made only in large sizes.

Conventional dry-dehydration processes are not suitable for wellhead installations. Conventional units are too large, too expensive in initial cost and in operating costs, and do not permit flexible operations. Several thousands of pounds of desiccant are required to dehydrate even small gas streams of 5 MMcf per day or less. The operation of conventional units is not efficient at varying flow rates if cooling water is not available. Units with gas-to-gas heat exchangers to condense the vaporized water cannot be operated efficiently at gas-flow rates lower than about 50 percent of the maximum design flow rate.

DEVELOPMENT OF WELLHEAD ADSORPTION EQUIPMENT

Selection of Basic Process. The major limitations of the dry-desiccant adsorption process for wellhead applications are high costs, large size, and inflexible operation. Inasmuch as there are no fundamental limitations of the basic method, this process was chosen as the one for development into a low cost and practical wellhead unit. Hydrocarbon-recovery considerations made this a logical choice. Dry desiccants are capable of adsorbing the heavier hydrocarbon fractions from a gas stream in the same manner as water vapor is adsorbed.

The adsorption of hydrocarbons on a desiccant is somewhat more complex than the adsorption of water vapor, but the process has no inherent limitations as does the low-temperature separation process. It is easily possible to remove from 50 to 80 percent of the stable hydrocarbon fractions from a gas by adsorption at usual pipe line conditions of temperature and pressure.

Size Reduction of Process Vessels. Because quantity of desiccant determines the size of the vessel containing it, consideration was given to the possibility of reducing the quantity of desiccant without sacrificing overall plant capacity. Laboratory studies indicated that design criteria commonly used in the design of adsorption plants specified many times the quantity of desiccant that was actually necessary for a given capacity. These studies indicated that only a fraction of the amount of desiccant as specified by the accepted criteria could be used to dehydrate gas in a wellhead unit. To achieve this maximum capacity of adsorption from a dry desiccant requires the efficient application of what is termed "dynamic adsorption."

To substantiate the incredible results of the laboratory calculations and studies, field tests were made with beds of desiccant in pressure vessels operating under actual field conditions. Results from these tests were

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very encouraging, in that all question was removed that small bodies of desiccant could be made to do a relatively large job of adsorbing water.

From the data obtained from these single-test packs, twin-pack semi-automatic units were designed and put into operation.

Based on results obtained from Carthage field tests, desiccant pack sizes were calculated for the range of dehydration requirements needed in wellhead units. Figure 3 illustrates the contrast in weight of desiccant required for a wellhead unit and that used in some conventional dehydration plants. Design for a wellhead unit specifies that the processed gas shall have a water content of less than 7 pounds per million at all times. To be safe, the quantity of desiccant actually required is doubled to allow for decreased efficiency of the desiccant with time.

Factors that determine the useful life of a desiccant are unknown with the exception of those that mechanically destroy the ability of the desiccant to function. Coating of the surface by tarry material, disintegration of the desiccant by flooding of the bed with liquid, and the powdering of the desiccant are some of the obvious causes of desiccant failure.

The number of cycles of adsorption and regeneration is sometimes used as a yardstick of useful desiccant life. This is of extreme importance in the operation of a small well unit as short time cycles, two hours or less, are desirable. To study the effect of rapid cycling on a desiccant, samples of desiccant were taken from beds that were in continuous service.

A sample of desiccant that had been subjected to 3000 cycles of adsorption and regeneration still had 90 percent of the capacity of new desiccant. Desiccant used in large conventional dehydration plants ordinarily is expected to last 500 to 1000 cycles before being renewed. Sufficient data have been taken on desiccant life in the wellhead units at this time to be certain that the number of cycles of saturation and regeneration is not the controlling factor in desiccant life.

Having thus determined that a small body of desiccant could perform the adsorbing job required, and that the life of the desiccant would not be shortened by the unusual treatment in the wellhead unit, designs were made for twin desiccant pack adsorption units using desiccant bed sizes.

Reduction in weight of the desiccant vessels not only serves to reduce manufacturing cost, but also reduces the overall heating and cooling requirements.

Vessel Assembly. In the usual dehydration plant, several pressure vessels are required, and these in turn must be interconnected by piping and valves. Pressure vessels are costly, as is the piping required to connect them in the final assembly. One of the most expensive items is the large high-pressure motor valves as required for switching the main gas flow and regeneration gas flow.

By the use of such a unitary vessel, the expense of the interconnecting piping and valving disappears; there is none required. A full-opening, zero leakage three-way valve located at the junction of the outlet lines from the two desiccant packs serves to direct flow through the tower which is adsorbing. A small high-temperature three-way valve serves to switch the flow of hot gas from the heater through the bed that is regenerating. These three-way valves constitute the entire valving required.

Figure 4 is a schematic flow diagram of the arrangement of the parts of the unitary vessel which minimizes interconnecting piping and valving.

Heat Balance. Perhaps the one greatest drawback to the conventional dry-desiccant unit is the inflexibility of operation. The basic design of such units requires a large stream of gas for the heating of the packs for regeneration, and this stream of regenerating gas must be cooled after passing through the pack. Such cooling of the regeneration gas stream may be accomplished by heat exchange with the gas flow leaving the unit. If the main flow is reduced by one half, then only half enough cooling gas is available; and the result is that the regeneration gas is inadequately cooled.

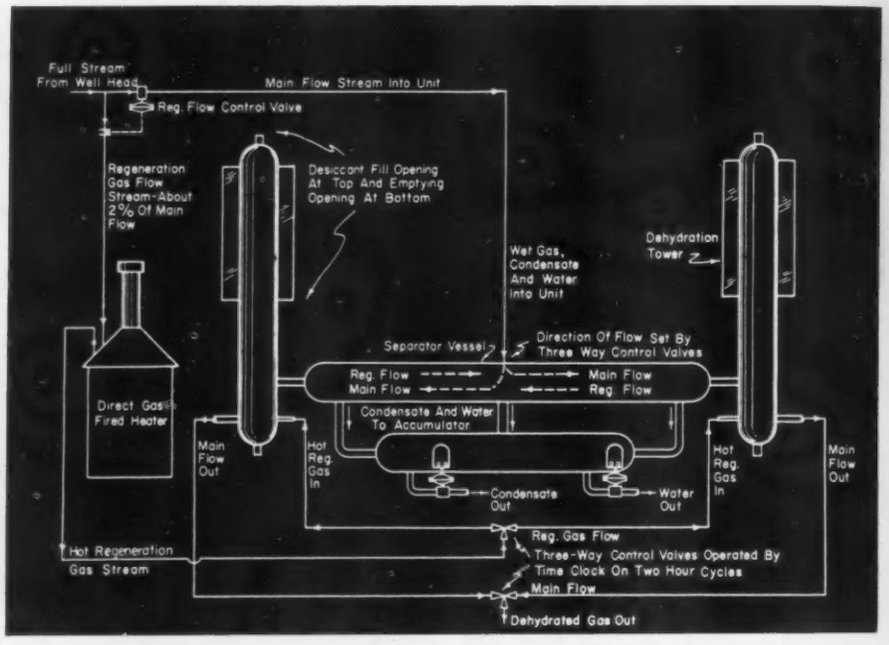

Full Stream From Well Head
Main Flow Stream Into Unit
Reg. Flow Control Valve
Regeneration Gas Flow Stream-About 2% Of Main Flow
Desiccant Fill Opening At Top And Emptying Opening At Bottom
Wet Gas, Condensate And Water Into Unit
Dehydration Tower
Separator Vessel
Direction Of Flow Set By Three Way Control Valves
Reg. Flow
Main Flow
Main Flow
Reg. Flow
Direct Gas Fired Heater
Condensate And Water To Accumulator
Main Flow Out
Hot Reg. Gas In
Condensate Out
Water Out
Hot Reg. Gas In
Main Flow Out
Hot Regeneration Gas Stream
Reg. Gas Flow
Three-Way Control Valves Operated By Time Clock On Two Hour Cycles
Main Flow
Dehydrated Gas Out

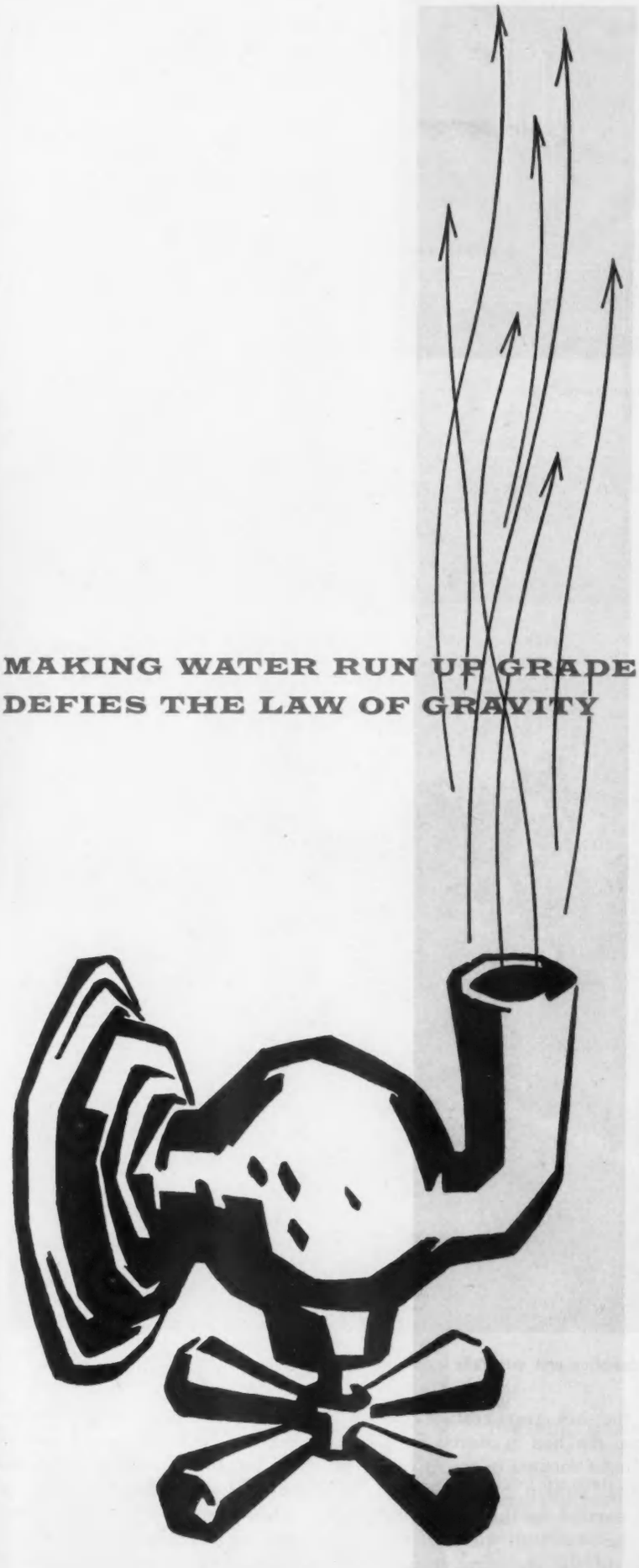
FIGURE 4—A minimum of piping and valving.

Under such conditions, the hot saturated gas which contains a relatively immense quantity of water goes into the main stream entering the tower being saturated. This increases the water load on this tower and also increases the gas temperature, with the net result that efficiency may be reduced to the point where the dehydration process practically stops.

A large part of the water adsorbed in the towers may thus be shuttled back and forth between the towers in the hot regeneration gas stream with very little dehydration of the stream flowing through the unit.

The solution to this problem is to use a water-cooling system, but this necessitates a source of water and power to circulate it through the cooler. Neither the water nor the power are ordinarily available at an isolated well.

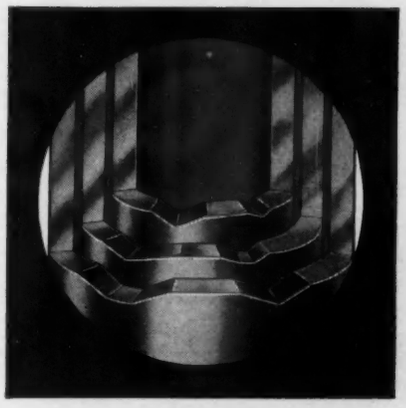
Thus, there had to be a better sys-



MAKING WATER RUN UP GRADE DEFIES THE LAW OF GRAVITY

Lifting water in the oil fields presents a like problem—whether it be a water supply well for a flood or just a plain wet oil well.

Fluid Packed Pump Co., in recognition of the Oil Industry's need for a Down Well Rod-Drawn Pump that will economically and efficiently handle large volumes of water, has applied the Multiple Tube Principle to its design of an over-size pump. The Multiple Tube Pump, by reason of its sleeve type construction, will maintain its maximum rate of efficiency in water, and does not require lubrication for successful operation.



The fluid packing between the tubes eliminates the need for lubrication.

The **OVERSIZE OILMASTER MULTIPLE TUBE PUMP** can be installed or removed on the rod string. The pump can be seated in a shoe on the bottom of large tubing or on a Packer Type, vertically setting Pump Anchor designed to set in the casing string.

SPECIFICATIONS

Pump Bore	Pump O.D.	Tubing or Casing Size	Bore Factor*	Maximum Stroke
2¼"	2¾"	3" or larger	0.590	166"
2¾"	3¾"	4" or larger	0.881	166"
3¼"	3¾"	4" or larger	1.232	166"
3¾"	4"	5½" or larger	1.640	166"

*BORE FACTOR X STROKE LENGTH IN INCHES X STROKES PER MINUTE EQUALS BARRELS PER 24 HOURS.
EXAMPLE: 1.640 X 74" STROKE X 15 SPM–1,820 BARRELS.

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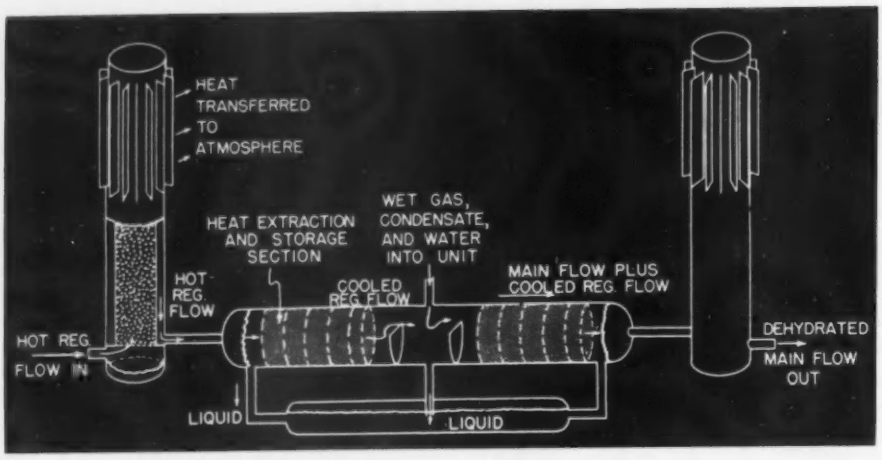


FIGURE 5—Unique heat storage method diagrammed.

Thus, the hot gas stream from the pack being regenerated is cooled to the temperature of the main stream before admixing. The water content is the same, and there is no increase in temperature or water load of the gas going to the saturating pack.

The stored heat has not been removed from the system; it is only stored, and must be removed ultimately. The schematic drawing, Figure 5, shows that there are twin heat-storage masses in the horizontal-vessel section; and as the cycle switches, flow reverses direction from the central point of entry of wet gas.

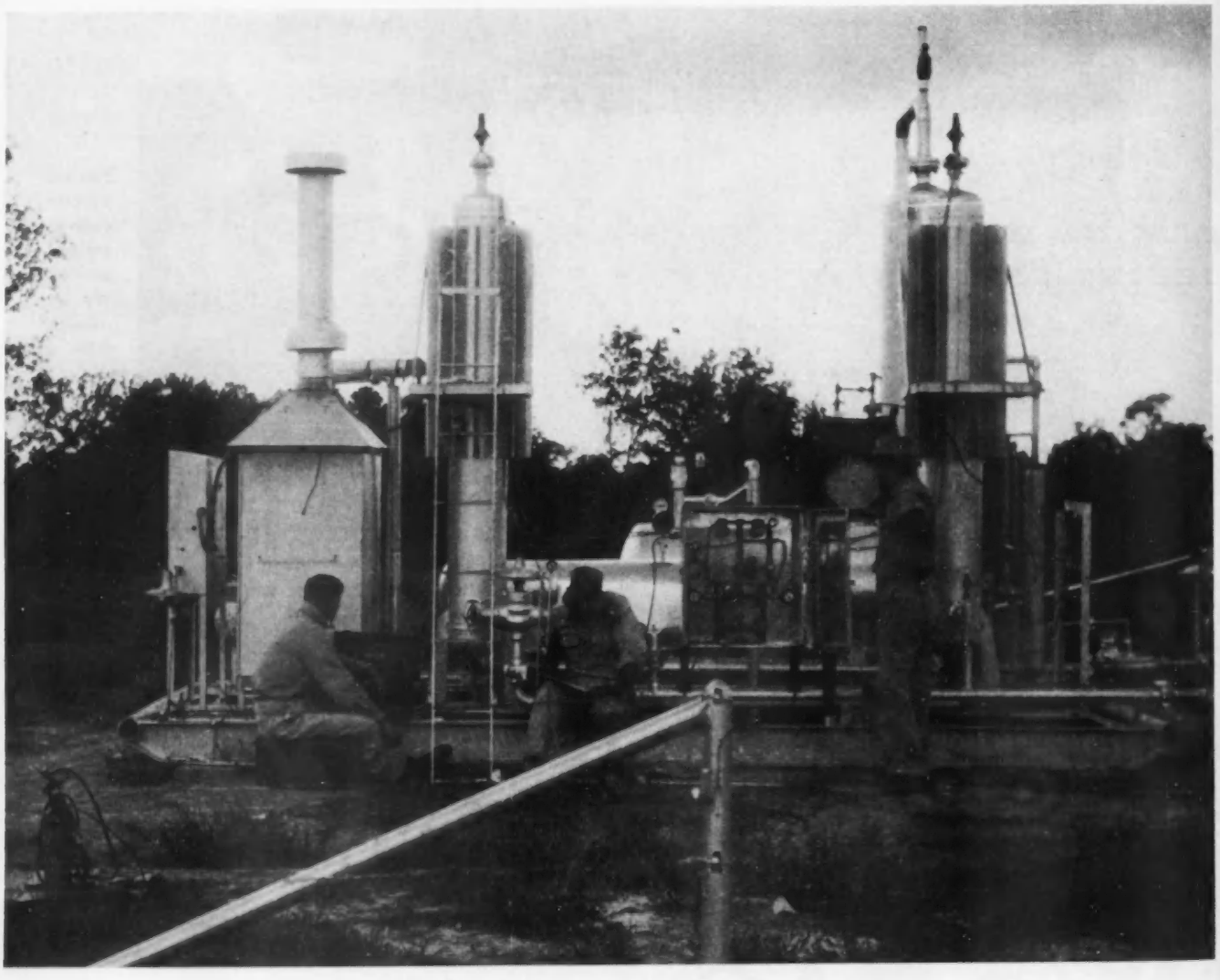


FIGURE 6—Wellhead adsorption unit with fully automatic controls.

tem developed for cooling the hot regeneration gas other than by heat exchange. Complete flexibility of a wellhead unit from zero flow to maximum is a must, and water cooling was out of the question.

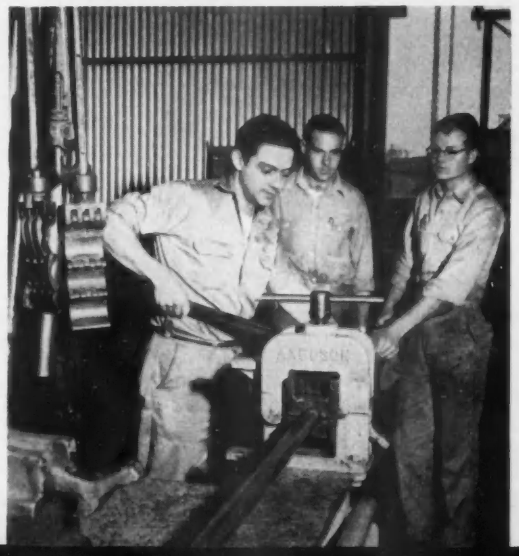
The solution is this: The heat contained in the hot regeneration gas stream from the bed is stored in a mass of material located in the end of the horizontal section of the vessel, and is not carried by the gas to the center of the vessel to increase the temperature of the incoming stream.

The adsorptive capacity is momentarily reduced by the increase in temperature; but this increase in temperature is of very short duration, and is a time when the pack is freshly regenerated with adsorptive capacity at the maximum, so there is very little if

AXELSON PICTORIAL

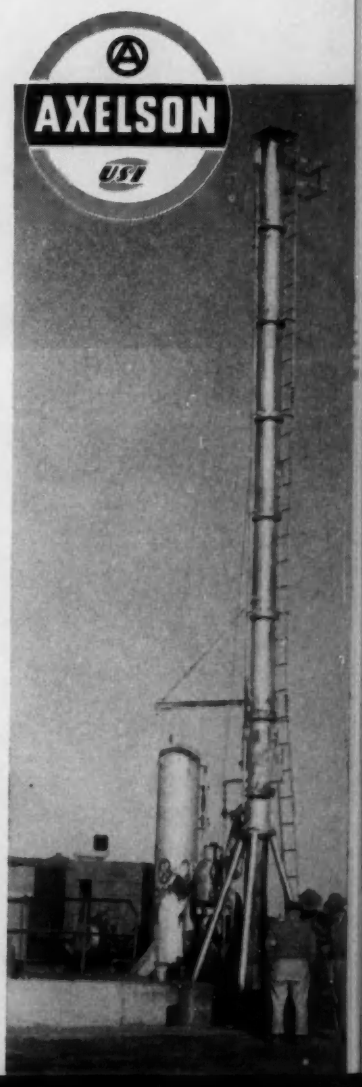
PROUD FATHERS. This is the backfield for New London High School, Texas. They won the area championship and went on to compete for the state title. In Texas, competition for state honors—well, there's none tougher. The players are all sons of oil men. Left to Right (front row): Jackie Sledge QB, Don Allen FB, Joe Allen HB, Joe Hughes T, Johnny Dickerson QB, Tom McClellan HB, Burna Battles FB. (Back row): Sledge, Humble Oil Company; Allen, Humble Oil Company; Hughes, Sun Oil Company; Dickerson, Humble Oil Company; McClellan, Humble Oil Company; Battles, Atlantic Refining Company. Oilmen also have a championship team in production equipment—Axelson deepwell pumps, sucker rods and hydraulic pumping units.

LEFT TO RIGHT. In front of the Axelson pumping unit (shown at right) are three important members of Leland Fikes' production department: C. W. "Kelly" Lindholm, Lease Foreman; A. D. (Dale) Mortimer, Field Superintendent; Roy Walline, Roustabout. *According to company records, the Axelson unit paid out in nine months.*



960 BPD. This hydraulic pumping unit was installed at Lindsborg, Kansas, May 27, 1951, and was one of the early models built by Axelson. It pumps 960 BPD from 3,300 feet at 6 strokes a minute. A 2¼ Axelson TLE Tubing Pump is at bottom and an Axelson sucker rod string completes the hookup. Axelson Long-Stroke pumping units are recommended for greater production at slower pumping rates, greater depths, less turbulence at well bottom and less wear and tear on subsurface pumps and rods.

TUNESMITH. Making up an RLA pump is Axelson's pump repair crew at the store in Long Beach, California. (Left to right) Bob Campbell, Earl Kirby (Store Manager), Herb Rainbolt. Campbell has written several successful songs for such able performers as Stan Freiburg and others. His latest is "I'll be Kind," recorded at Capitol Records, Hollywood, by a vocal group. Bob is now the new Axelson store manager at Ventura.



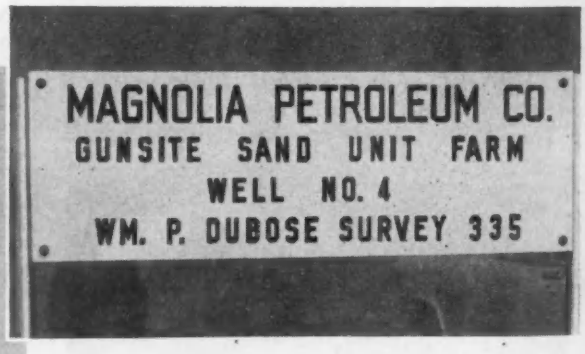
A LESSON IN PUMP SERVICE FOR A MAN FROM INDONESIA

Peter C. "Pete" Staats is a Petroleum Engineer for Standard Vacuum Oil Company in Indonesia. The wells under his jurisdiction are in the Lirik Field on the island of Sumatra and although they are presently flowing, they will soon go on the pump. He was born and raised in Holland before his assignment in the Dutch East Indies. Last December he visited the United States to study production techniques in this country, under the direction of D. A. Murphy, District Superintendent for Magnolia Petroleum Company.

At Magnolia's Gunsite Sand Unit Farm near Electra, Texas, Pete saw firsthand how a pump is pulled, repaired, transported and replaced in the well with a minimum loss of time and production. At 9 A.M., the lease foreman called the Jones and Laughlin store in Electra and ordered a pump delivered "right after lunch." The pump in the well was being pulled and was expected to be out just before the lunch hour. The new pump was at the site on time and went back in the well with no loss of rig time. The photographs describe the sequence of events.

IT BEGINS HERE. While the subsurface pump is being assembled in the shop at Jones & Laughlin's store at Electra, Texas, Joe Fitts (left), the Axelson Representative from Graham, Texas, explains the various combinations of Axelson pumps for virtually every type of oilwell service, while Pete Staats (center) and T. M. Bailey, J & L store manager, listen.

ALL SET. The pump is strapped to the pump rack of Joe Fitts' car by W. E. Cude, Storeman, where it will be delivered directly to the well. Axelson and J & L men carry these car racks for this type of service and it is unusual when they do not put 50,000 miles on a car within a year. They are on call around-the-clock and attend more night and emergency calls than a doctor.



EARLY ARRIVAL. The pump is delivered to the well with time to spare. This is one of Magnolia's portable pulling rigs. Pete meets the members of the crew and listens to their stories while they finish eating lunch. He gathers valuable on-the-scene information he will take back with him to Indonesia.

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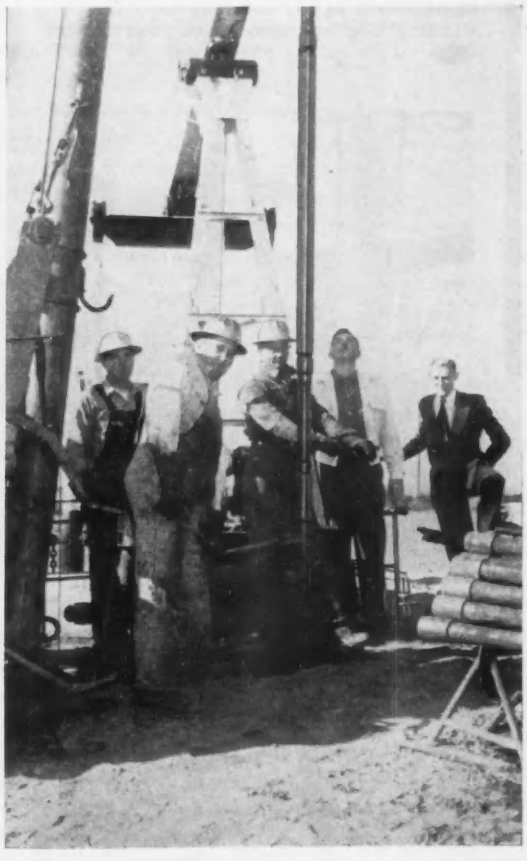
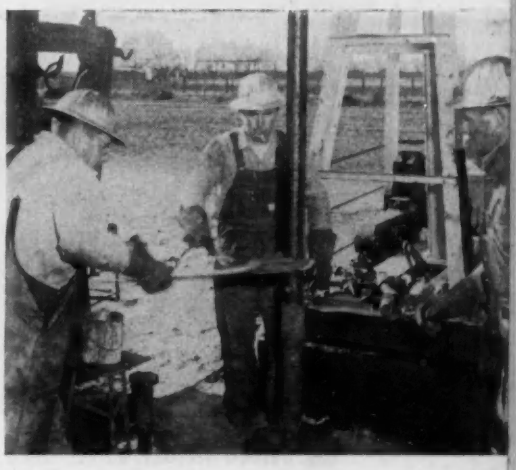
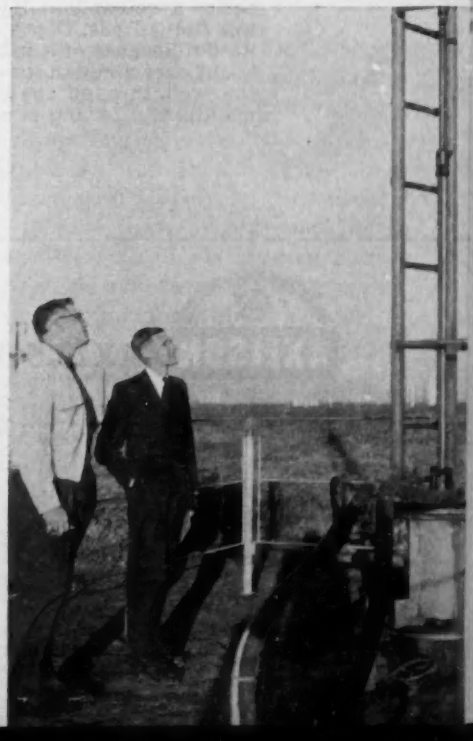
OFF SHE COMES. The pump is removed from the car and placed on the tubing rack by three members of Magnolia's well-servicing outfit. Left to right: (lower photo) C. D. Gee, G. R. Walhup, Leroy Cotton. Gee, the gang pusher, has been with Magnolia over 18 years and has handled many an Axelson pump in his time.



MISSION ACCOMPLISHED. The last length of tubing is being made up and the well will soon be on production again. Twenty-six barrels of 40 gravity crude oil are pumped daily from 1,860 feet. Axelson pumps are specially equipped to combat severely corrosive conditions.



SHORT STROKE. A few miles away near Hollyday, Texas, Pete observes an Axelson Hydrax hydraulic pumping unit in operation for Cities Service Oil Company, while Joe explains its advantages. This is a 6 ft. stroke "Pedestal Mount" Model H100. It is also made with a 10 foot stroke. The Axelson Hydraulic Long Stroke pumping unit (25 ft.) is recommended for greater depths and greater production.



PIPE DOWN. The Axelson pump is being lowered into the well with the first length of tubing while Joe and Pete look on. Joe brought back the pump that had been pulled. The plunger was corroded by electrolysis. New parts were inserted from stock and pump was again ready for active duty.

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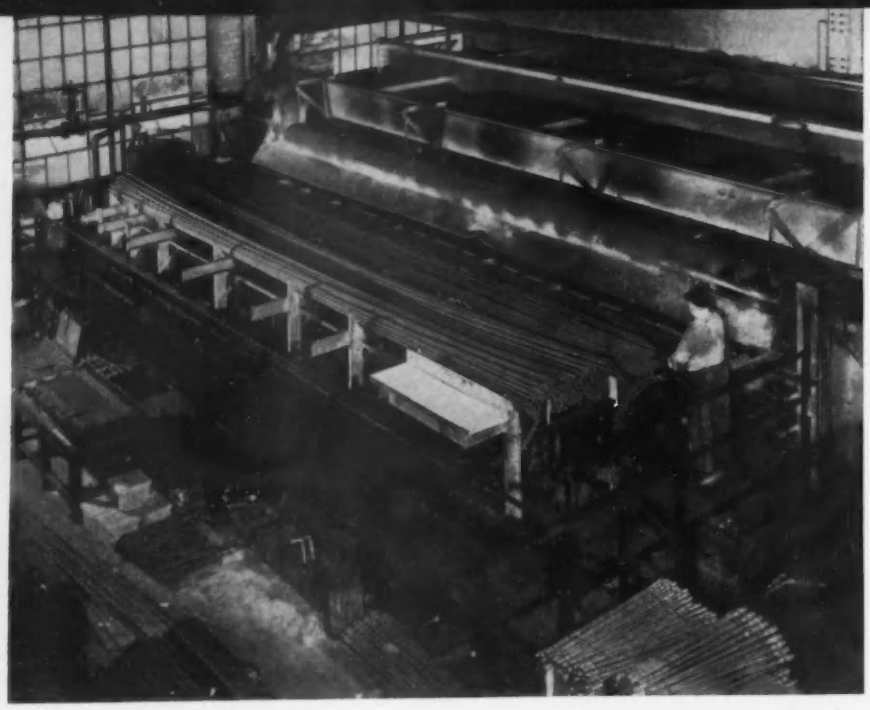
AXELSON PICTORIAL



16 TONS. ⅞" sucker rods are in process of manufacture at Axelson's St. Louis plant devoted *exclusively* to the fabrication of sucker rods, couplings, polished rods and a complete line of hollow sucker rods. After having been upset on both ends, the rods are ready for heat treatment where all stresses and strains are removed. Axelson was the first to normalize and temper sucker rods throughout their entire length. Axelson was also the first to employ nickel-molybdenum steel in sucker rods suitable for heavy loads and resistance to corrosion.

SANTA FE SPRINGS. Sig Benson (left), Production Foreman for Bandini Petroleum Company, and Mark Ward, Axelson District Manager, smile for the camera in front of the Off No. 9 at Santa Fe Springs. Because of an abrasive condition in this well, the pump was pulled about every four months. After being equipped with Axelson Duax Liners, the pump has been in the well over a year with the same liners (as of January 30, 1956). The Axelson Stuffing Box has also given good service.

HOLLOW VICTORY. R. R. "Rudy" Stafford, District Production Foreman for Pan American Production Company, stands beside a well at Port Barre, Louisiana, equipped with Axelson Hol-O-Rods. Depth 4,833 ft.; production 25 B/D; gravity 36. Because of a paraffin condition, the well was pulled about once a month for cleanup. Now, steam is injected into the well through the hollow sucker rods about every 3 months and pulling is no longer necessary.

No. 2

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any disturbance in the overall adsorptive efficiency of the unit.

Controls. In order to realize the maximum performance from a bed of desiccant, the heating and cooling cycles must be properly controlled, much more accurately than is ordinarily done in a conventional plant using a large mass of desiccant.

It is imperative that the desiccant bed in a wellhead unit be completely regenerated during each cycle. If insufficient heat is applied to the pack to accomplish this, part of the bed is left in a saturated condition, which reduces the effective size of the desiccant bed for the subsequent saturating cycle. Reduced bed size means reduced adsorbing capacity. The continued application of heat to the desiccant bed after regeneration is complete may be equally bad for the overall efficiency of the wellhead unit.

Most of the units presently in the field are equipped with electrical control systems. The electrical power is generated by a commercial thermopile incorporated in the pilot burner of the heater. The thermopile output also serves as a safety cutoff for the heater fuel in the event of a pilot burner outage.

A time-cycle controller driven by a clock has been used to switch flow and start the heater burner at the beginning of a regeneration cycle. A temperature-sensing element located within the desiccant pack signals the time at which regeneration is complete, and this signal cuts off the fire in the heater. When the pack is cooled, the time clock switches flow and starts a new cycle.

The rate of heat input into a bed during regeneration is a function of rate of regeneration-gas flow and its temperature. Thus, it is important that this rate be held to the required amount in respect to the flow of the main gas stream through the unit. The temperature of the gas from the heater is controlled by a thermostat in the heater outlet line.

Control of the throttling motor valve by a device sensing the temperature in the line is more difficult than first thought. The change in temperature of the gas relative to the change in pressure drop is small, and when a temperature-sensing element is installed in the customary thermometer well in the flow line, a relatively long time is required for the element to sense a small change in flowing-gas temperature, convey the information to the controller, and for the controller to position the motor valve. The various standard devices installed in this manner would not give stable control; serious cyclic fluctuations of pressure resulted.

Stable control of this valve was ultimately achieved by developing a temperature-sensing device which is clamped on the outside of the pipe carrying gas to the unit. The changes in length of the pipe caused by small temperature changes are sufficient to actuate a controller which, in turn, positions the motor valve.

A unit equipped with a completely automatic control system is shown in Figure 6. "Completely automatic" is used in the sense that the unit switches its own cycles based on the heat conditions within the packs. No clock for timing is used in the system.

Each tower has a special temperature-sensing element installed in the desiccant pack. These elements actuate pilot mechanisms which may be seen extending from the top of each tower. The pilots transmit signals to the central control box, which appears in the picture between the two towers.

At the start of a cycle, hot gas starts to flow into the bed that has been saturated; the bed is cool. When sufficient heat has been put into the pack to completely regenerate it, the temperature-sensing element in the pack cuts off the fire in the heater, and the cooling period begins. When the pack has been cooled the temperature-sensing element acts to switch flow through the bed, and at the same time to start the fire in the heater. Thus flow of heat to the desiccant bed is cut just at the point of complete regeneration, and the cycle is switched just as soon as the bed has been cooled.

Early in the testing period of twin-bed units it became apparent that stock three-way valves would not be suitable for wellhead unit flow control. Some of the valves available had restricted flow areas that would cause undue pressure drop; others used metal-to-metal seats which invariably leak to some extent. In all cases, conventional three-way valves complicate piping assembly, especially when the piping has to be arranged for dismantling to enable the lower seat of the three-way valve to be serviced.

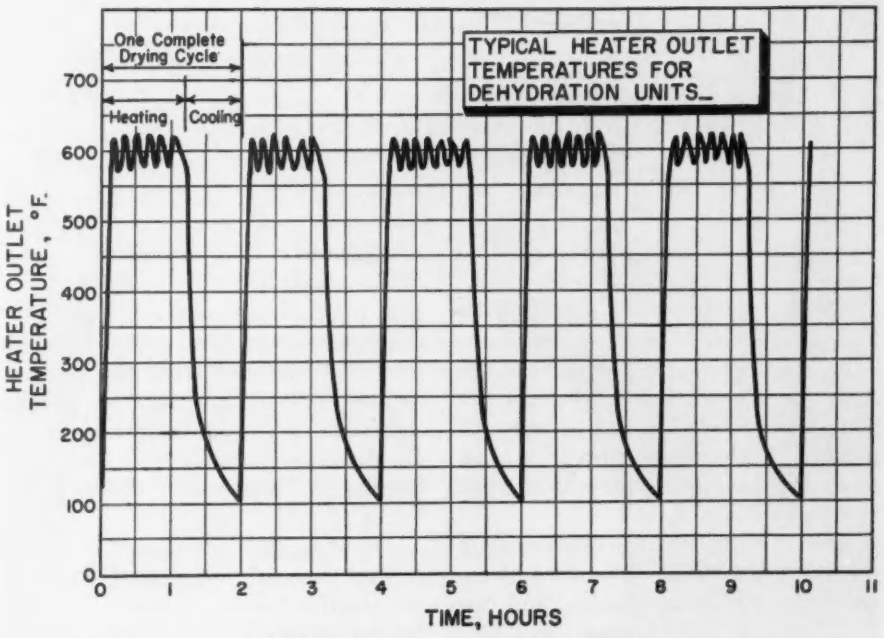


FIGURE 7—Close heat control is beneficial.

Full-opening three-way valves were designed for this service. They are equipped with resilient seats to assure zero leakage, have unrestricted flow passage, and all of the internal parts of the valve may be removed through the top opening of the body.

It might appear that the importance of valve leakage was being unduly emphasized; this is not the case. In the operation of wellhead dehydration units, the stream of gas used for regeneration is frequently less than 2 percent of the flow through the unit. The importance of supplying the correct quantity of heat to the pack to

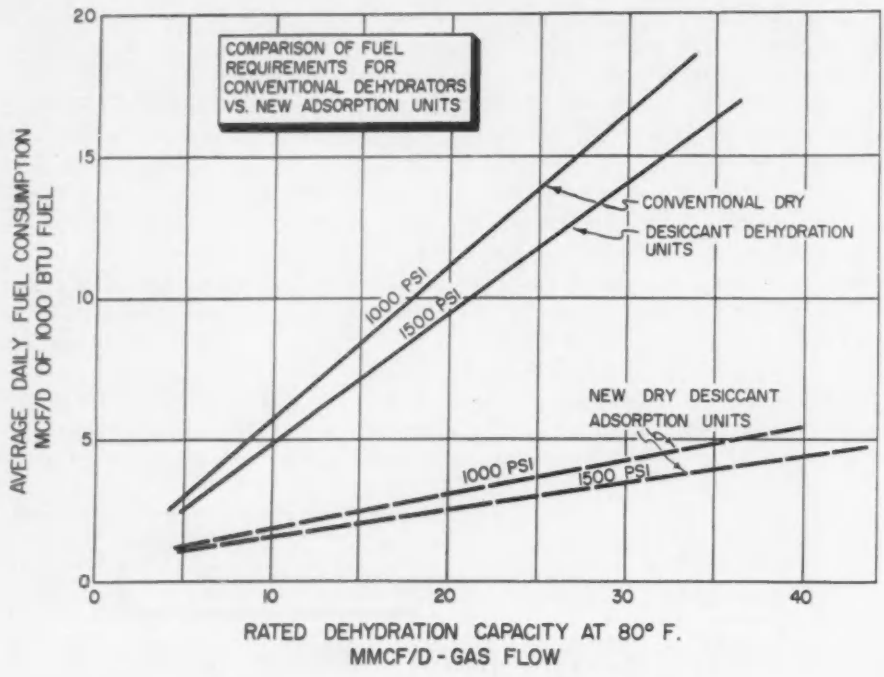

COMPARISON OF FUEL REQUIREMENTS FOR CONVENTIONAL DEHYDRATORS VS. NEW ADSORPTION UNITS
CONVENTIONAL DRY
DESICCANT DEHYDRATION UNITS
1000 PSI
1500 PSI
NEW DRY DESICCANT ADSORPTION UNITS
1000 PSI
1500 PSI
AVERAGE DAILY FUEL CONSUMPTION MCF/D OF 1000 BTU FUEL
RATED DEHYDRATION CAPACITY AT 80° F. MMCF/D - GAS FLOW

FIGURE 8—New units require less fuel.

regenerate has been discussed. The heat supplied is directly dependent upon the amount of gas flowing through the pack to effect regeneration. In a case where 2 percent of the throughput were being used for regeneration, valve leakage of only 0.5 percent of the throughput would cause the pack to be only 75 percent regenerated.

Large conventional dehydration plants require about 10 percent of the throughput for regeneration, and can better tolerate valve leakage.

Wellhead adsorption units are frequently installed in isolated places, with the rate of flow through the unit being controlled from a point on the line some distance from the well. If for any reason flow through a unit should be stopped, the heater should not be allowed to come on as overheating of the heater tubes could result.

The most satisfactory and foolproof control system has proved to be a pneumatic device. A temperature-sensing element is installed in a deep well located inside the inlet pipe to the heater. The well and sensing element are of sufficient length to extend well inside the heater firebox. Under normal flow conditions, the incoming regeneration-gas stream maintains the temperature-sensing element at line temperature. Should flow through the regeneration system stop and the fire remain on, this section of the inlet pipe to the heater will immediately start to heat. The control is set to block the burner fuel when a relatively slight rise in temperature occurs at this point.

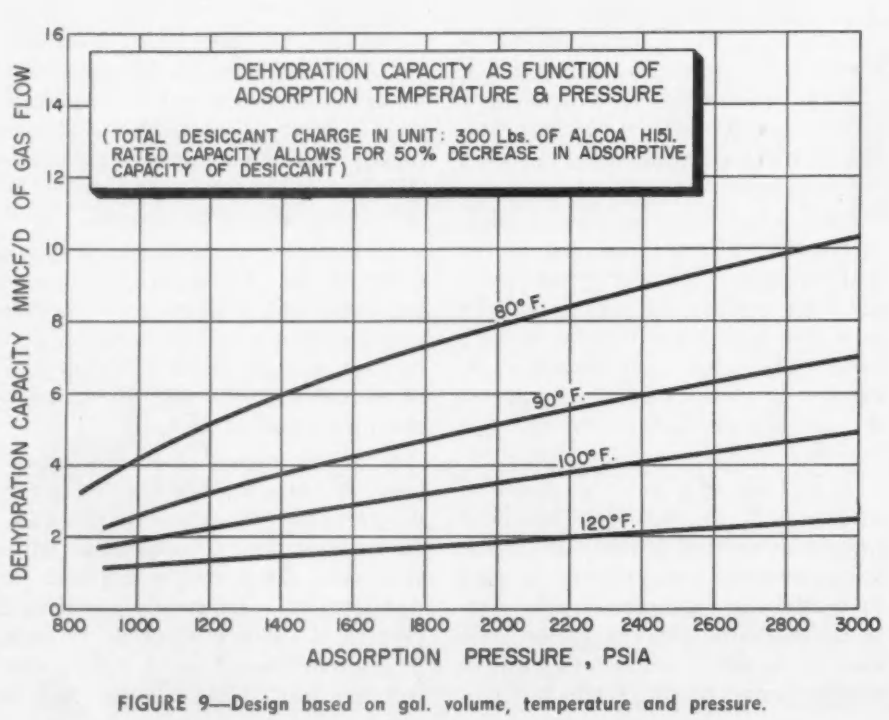

DEHYDRATION CAPACITY AS FUNCTION OF ADSORPTION TEMPERATURE & PRESSURE
(TOTAL DESICCANT CHARGE IN UNIT: 300 Lbs. OF ALCOA H151. RATED CAPACITY ALLOWS FOR 50% DECREASE IN ADSORPTIVE CAPACITY OF DESICCANT)
80° F.
90° F.
100° F.
120° F.
DEHYDRATION CAPACITY MMCF/D OF GAS FLOW
ADSORPTION PRESSURE, PSIA

FIGURE 9—Design based on gal. volume, temperature and pressure.

Heater. Design and development of a heater of suitable characteristics for use in the wellhead adsorber required considerable time and effort.

Field-test data taken at Carthage indicated that higher regeneration efficiency could be had by heating the regeneration gas to a temperature somewhat higher than that commonly used in conventional dehydration plants. It was decided to use a regeneration-gas temperature of 600° F.

The use of salt-bath or vapor-type heaters was not practical, so a direct-fired heater was developed. Figure 7 shows typical heater outlet temperatures. Heaters have been built in capacities ranging from 50,000 to 1,000,000 btu per hour.

Results of the development program on the heating unit are not immediately visible; the benefit is in the form of unburned gas that goes into the pipeline. Figure 8 lists the fuel requirements for the wellhead dehydration units as compared with conventional dehydration units.

Pressure Drop. The use of equipment using small beds of desiccant raises the question of pressure drop under operating conditions. When pressure drop through a dehydration plant is mentioned, the tendency is to visualize the drop as occurring through the desiccant bed with very little if any consideration being given to pressure drop through the piping and valves. Analysis of the pressure drop through several plants indicated that this impression is erroneous. The greater part of the total pressure drop across a plant is in the piping and valving.

In one large conventional dehydration plant operating at the rated capacity, pressure drop through the bed was 3 psi; over-all plant loss of pressure was 18 pounds. A similar study

of a large wellhead unit showed a 5-pound drop across the bed, with an over-all pressure drop of 12½ pounds across the unit.

The explanation for the low over-all pressure drop through the wellhead unit is the simplified piping and the use of a single full-opening three-way valve to control flow instead of the multiple valving necessary in conventional plant flow patterns. Pressure drop through the heat exchanger of the conventional dehydration plant was 4 pounds. In heat-exchange equipment pressure drop is necessary for efficient heat exchange. The wellhead unit has no heat exchanger, so this addition to the over-all pressure drop is zero.

FIELD INSTALLATIONS

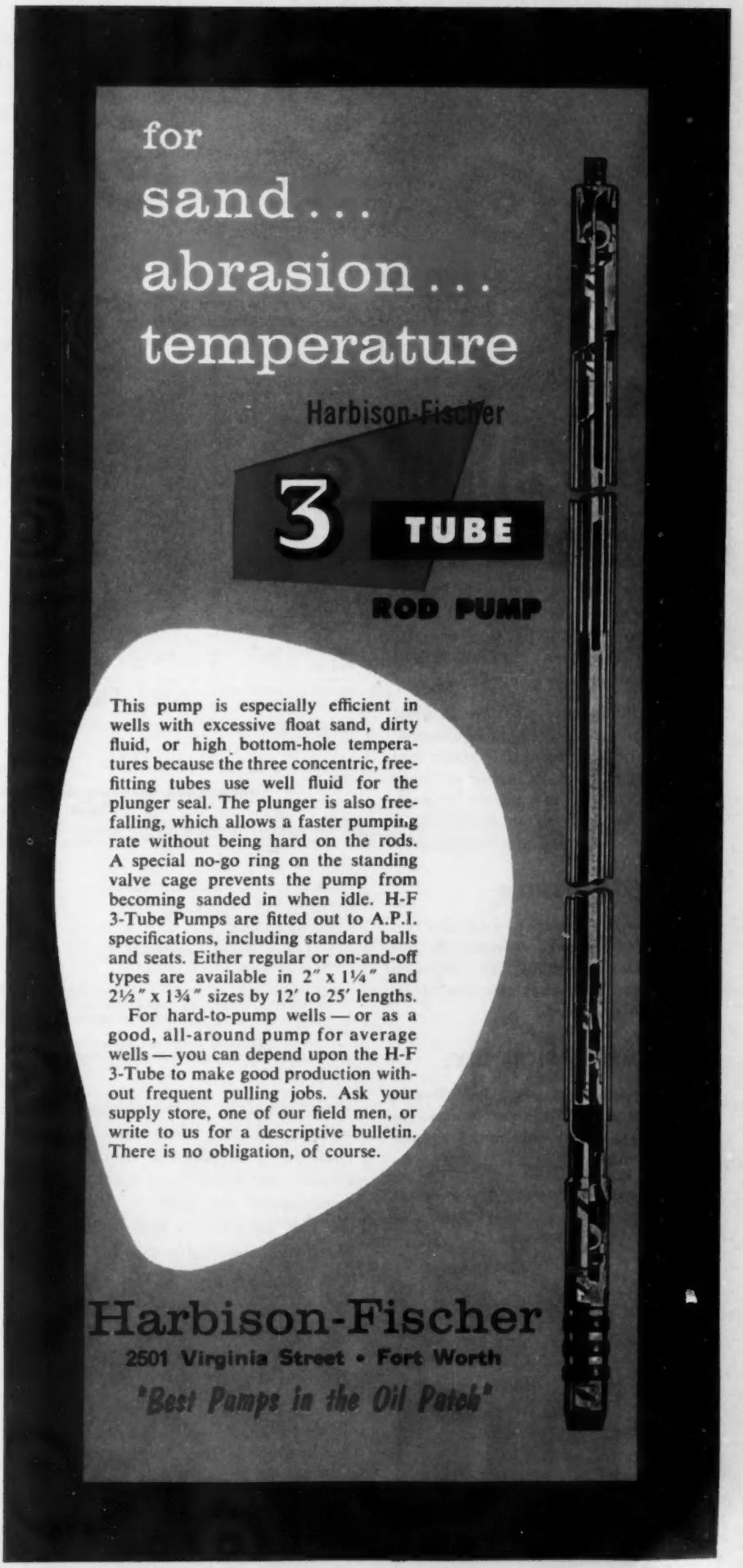
Wellhead adsorption units have been installed and operated under widely varying conditions. Operating pressures have ranged from 50 to 3500 psi, and temperatures have ranged from 45° to 120° F. Some 24 of these units have been placed in operation to this time, with applications ranging from simple dehydration to maximum hydrocarbon recovery.

A summary is given in Table 1 of the operating conditions and results of some of the field installations. Comparative hydrocarbon-recovery tests were made on a hydrocarbon adsorption unit and a low-temperature separator which were installed in parallel on a high-pressure gas-condensate well in south Louisiana. The operating conditions and results of the comparative recovery tests are given in Table 2.

APPLICATION OF WELLHEAD UNITS

Out of this development program has evolved some basic components for adsorption-unit applications at the wellhead. The components may be modified and arranged to suit specific requirements.

Simple dehydration of natural gas by the use of a wellhead unit requires no variation in the combination of the basic elements which comprise the complete unit. The quantity of gas to be dehydrated, with its inherent water-vapor load which is fixed by temperature and pressure, determine the size of the equipment. Thus, dehydration equipment may be designed on the basis of gas volume, temperature, and pressure. For illustration,


for
sand...
abrasion...
temperature
Harbison-Fischer
3 TUBE
ROD PUMP
This pump is especially efficient in wells with excessive float sand, dirty fluid, or high bottom-hole temperatures because the three concentric, free-fitting tubes use well fluid for the plunger seal. The plunger is also free-falling, which allows a faster pumping rate without being hard on the rods. A special no-go ring on the standing valve cage prevents the pump from becoming sanded in when idle. H-F 3-Tube Pumps are fitted out to A.P.I. specifications, including standard balls and seats. Either regular or on-and-off types are available in 2" x 1¼" and 2½" x 1¾" sizes by 12' to 25' lengths.
For hard-to-pump wells — or as a good, all-around pump for average wells — you can depend upon the H-F 3-Tube to make good production without frequent pulling jobs. Ask your supply store, one of our field men, or write to us for a descriptive bulletin. There is no obligation, of course.
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. . . from ⅓ HP to 300 HP . . . from 20 bbls to 25,000 bbls . . . from 200' to 10,000' and more . . . Yes, a REDA will do that pumping job BETTER . . .

Reda Pumps are used as original equipment, or replacement equipment, because they produce at a lower cost per barrel of fluid. Whether it's large volumes from shallow depths, or modest volumes from great depths, Reda Pumps provide operating savings.

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Greatly improved overall efficiencies have improved Reda performance as much as 25%; a substantial operating saving.

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capacity curves for dehydration with a wellhead adsorption unit containing 300 pounds of desiccant and having towers built from 12-inch 3000-psi pipe are shown in Figure 9.

In general, an adsorption unit designed to recover the maximum of hydrocarbon from a gas stream will have much larger beds of desiccant than will units to dehydrate the same volume of gas. The capacity of any quantity of desiccant to remove hydrocarbons from the vapor phase is a function of the bulk of the bed and of the frequency with which it is saturated and regenerated.

For maximum hydrocarbon recovery, it is necessary to operate on as rapid a cycle of saturating and regenerating as possible. Rapid cycling requires a high rate of heat input to the desiccant bed to shorten regeneration time.

Cooling of the hot regeneration stream requires a corresponding increase in rate of heat dissipation.

In general, it is desirable to operate a hydrocarbon-recovery unit at pipeline pressures, 500 to 1200 psi, and not at higher pressures in order to obtain the maximum amount of natural condensation of hydrocarbon liquid. The additional recovery of liquid hydrocarbons results from the adsorption of hydrocarbon vapors from the separator gas by the dry-desiccant beds.

Depending upon the flowing pressures and temperatures of each individual well, it may be desirable to install a high-pressure dehydrator, a line heater, or a gas-to-gas heat exchanger upstream of the hydrocarbon-recovery unit. In some cases it is possible to throttle directly into the hydrocarbon-recovery unit.

Sufficient basic work has been done and operating experience gained on dehydration units to provide for the complete design of a plant for any natural-gas dehydration requirement. There is no size limitation on the basic dehydration design principles.

TABLE 1
Summary of Operating Conditions and Results of Field Installations

Size of Unit	OPERATING CONDITIONS			PRESSURE DROP		General Performance
	Flow	Pressure	Temp.	Across Bed	Across Unit	
12"—1500 psi..... 400 lbs. Desiccant...	½ to 1½ MMCF/D	500 to 700 psi	80° F	4 psi	25 psi	Outlet humidity about 1 lb./MMCF. Recovered 2 bbls./ additional liquid.
12"—3500 psi..... 300 lbs. Desiccant...	4 to 6 MMCF/D	3100 psi	95° F	10 psi	22 psi	Outlet humidity about 3 to 6 lbs./MMCF.
30"—1000 psi..... 2600 lbs. Desiccant..	5 to 10 MMCF/D	500 psi	90-95° F	4 psi	15-22 psi	Outlet humidity about 2 to 6 lbs./MMCF.
12"—850 psi..... 460 lbs. Desiccant...	1 MMCF/D	250 psi	85-90° F	5 psi	15 psi	Outlet humidity less than 2 lbs./MMCF. 1 to 2 bbls. per day of liquid recovery.
16"—1000 psi..... 700 lbs. Desiccant...	4 MMCF/D	800 psi	105-115° F	4 psi	20 psi	Outlet humidity about 4 to 7 lbs./MMCF.
12"—1000 psi..... 420 lbs. Desiccant...	1½ MMCF/D	800 psi	90-95° F	2 psi	7 psi	Outlet humidity about 1 lb./MMCF.
10"—850 psi..... 320 lbs. Desiccant...	1½ MMCF/D	500 psi	75-80° F	7 psi	11 psi	Outlet humidity 1 to 2 lbs./MMCF.

TABLE 2
Comparative Recovery Tests with Low-Temperature Separator and Well Head Adsorption Unit

	Low-Temp. Separator		Well Head Absorber	
	Test No. 1	Test No. 2	Test No. 1	Test No. 2
Length of Test	24 hrs.	24 hrs.	24 hrs.	24 hrs.
Rate of gas flow (MMCF/D)	4.3	4.2	4.4	4.3
Operating Pressure	950	950	920	920
Operating Temperature	20° F	20° F	45° F	45° F
24 Hour Ratio (Bbls./MMCF)	12.8	13.2	14.1	14.2
Total Stock Tank Liquid (Bbls.)	55.1	57.6	61.3	61.4

Additional stock tank condensate recovered by absorption in Well Head unit was about 7 to 8 bbls./day.
Additional stock tank condensate recovered by Well Head over Low-Temperature Separator was about 5 bbls./day.
GPM (gallons of pentanes plus per MCF) of outlet gas from Well Head unit was 0.080; and of outlet gas from Low-Temperature Separator was 0.125.

ACKNOWLEDGMENT

This article is a condensed version of a paper entitled Development of Dry-Desiccant Wellhead Adsorption Units and presented at the API Division of Production meeting, San Antonio, Texas, March 8, 1956.

At Camiri, Bolivia's investment in a government oil monopoly, Yacimientos Petroliferos Fiscales Bolivianos, paid off.

New Oil Law May Bolster Bolivia Economy

Backed by President Paz Estenssoro and government-owned oil company, petroleum code is generally favorable to foreign private capital.

By CORNELIUS H. ZONDAG
U. S. Operations Mission to Bolivia

BOLIVIA is betting heavily on a new resource: petroleum. After the silver mines of Potosi dwindled, the country practically disappeared from the economic scene until the discovery of tin rekindled national hopes early in the 20th century. Following this economic respite, Bolivia once again is wrestling with major economic difficulties.

The administration of President Paz Estenssoro, which took over in 1952, realized it must take measures to replace the declining income from minerals and to reduce a pyramiding need for food imports. So it did.

- First, an economic diversification program was begun to eliminate a $30 million annual food import bill by domestic farm efforts.
- Then, the government gambled on oil.

Immediately, several millions of dollars of Bolivia's precious foreign exchange were allocated to Yacimientos Petroliferos Fiscales Bolivianos, the government-owned oil company. Under the management of Eduardo Hinojossa and the President's brother José Paz Estenssoro, the investment paid off quickly.

Thirty-eight wells were drilled in the Camiri region, in southeastern Bolivia. Producing capacity began rising from slightly more than 1000 barrels daily in 1952 to a potential of 10,000 barrels a day in 1954, with reserves now estimated at some 60 million barrels.

For Bolivia this meant an immediate saving of $8 million dollars a year through elimination of fuel imports. Since domestic consumption of crude and crude products amounts to 5000 barrels daily, Bolivia now is exporting small amounts of oil to four neighbors—Argentina, Brazil, Chile and Paraguay.

And operations show no lessening. A new pipe line from Camiri field to the Argentine border was completed recently. A pipe line to La Paz is

Recently, this pipe line from Camiri field to Argentina border was completed.

Terrain at Camiri is rough.

under construction, and it, in time, may be extended to Arica on the Pacific coast. A small plant to manufacture lubricants for domestic use is scheduled for completion early in 1956.

But even with the success it has achieved, YPFB recognizes that by itself and without sufficient capital it cannot develop the Bolivian oil industry to the point where petroleum could replace the nation's present income from other minerals. So the national oil company has gone on record as being one of the strongest supporters of opening up the country to private investment by international oil companies.

What the new Bolivian petroleum law says . . .

AREA—Exploration area ranges from maximum 150,000 hectares in Zone 1 to 750,000 hectares in Zone 3, half of which must be returned to the government upon entering development stage. Minimum exploration area is 5000 hectares. The number of concessions held at any one time by one person or entity shall altogether not exceed from 500,000 hectares in Zone 1 to 3 million hectares in Zone 3. (1 Hectare equals 2.471 acres. Meter equals 3.28084 feet.)

TERM—40 years.

BONUS—Prospective concessionaires may offer special benefits. For this reason, an abstract of each application shall be published for 15 days to allow submitting of competitive applications.

OBLIGATIONS—Proof of technical and financial capacity must be established. Guaranty deposit of 5 to 20 cents (U. S. currency) per hectare, depending on zone, must be made. During exploration stage, concessionaire must spend annually in actual operations a minimum of 20 cents-80 cents, depending on zone.

EXPLORATION PERIODS—Zone 1—Maximum 4 years; Zone 2—Maximum 6 years—Zone 3—Maximum 10 years.

DRILLING OBLIGATION—During first 7 years of development, a minimum of 16,400 feet of hole must be drilled for each 100,000 hectares held. During next 8 years, a minimum of 32,800 feet of hole must be drilled for each 20,000 hectares held. Lack of drilling may be offset by paying a fee ranging from $20 to $30 for each meter not drilled.

ABANDONMENT—Concessionaire may relinquish his concession at any time, either totally or partially.

DEPLETION ALLOWANCE—Fixed at 27 percent of gross value of production, provided amount does not exceed 50 percent of net profits.

LAND RENTALS—During exploration stage, from 2 cents to 7½ cents (U. S. currency) per hectare per year, depending on zone and period. Initial development fee equals 40 cents per hectare in Zone 1, 30 cents in Zone 2, 20 cents in Zone 3. Development rentals range from 8 cents to $1.50 per hectare per year and are largely deductible from royalty.

ROYALTY—Fixed at 11 percent. At government discretion, royalty may be reduced to 7.5 percent for maximum of 15 years, except in Zone 1.

INCOME TAX—30 percent on all profits.

DEDUCTIONS—All exploration, development and drilling costs are deductible for income tax purposes. Annual losses may be carried over for a maximum of 7 years, while capital brought to Bolivia may be amortized at rate of 20 percent a year.

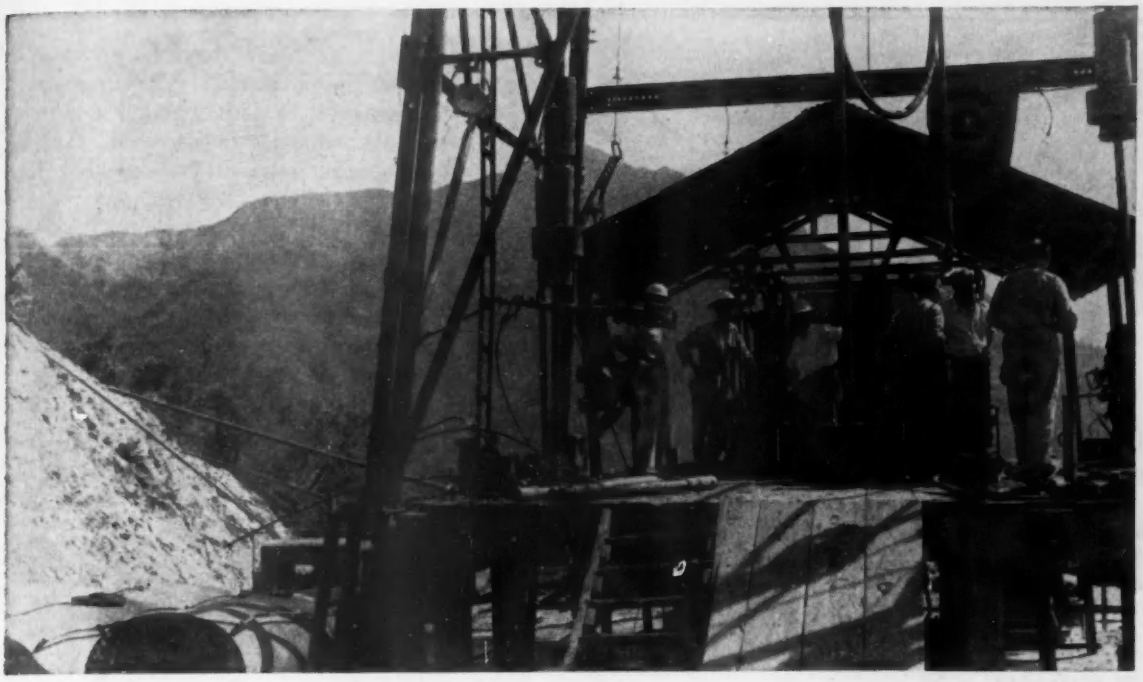
TAXES—All taxes, rentals and royalties—except development fee and special premiums—paid by concessionaire in any one year shall never exceed 50 percent of net profits. If net is greater than all payments combined, concessionaire will pay 50 percent tax on excess unless his profit, after paying income tax, should be less than 10 percent of non-amortized capital. If net is between 10 percent and 15 percent of investment, only half of excess will be taxed at 50 percent rate.

EXPORT—Exports of petroleum products by concessionaire are not taxable.

IMPORTS—Importation of machinery and equipment shall be duty free.

FOREIGN EXCHANGE—Concessionaire may retain full proceeds of sales in foreign exchange and deposit them in banks abroad.

PERSONNEL—At least 30 percent of upper level of employes and 85 percent of all laborers employed by concessionaire must be Bolivian nationals.



This shallow drilling rig is operating at Guayruy, near Camiri.

Bolivian President Paz Estenssoro (left) completes the final weld on the recently completed Cochabamba-Oruro-La Paz pipe line, which was built by Williams Brothers Sudamericana, Ltd. E. M. Hubach (center) is general superintendent of Williams Brothers operations in Bolivia.

Early in 1955, the U. S. Operations Mission to Bolivia, which has been helping Bolivia in the latter's efforts to diversify a lopsided economy, suggested that Bolivia try to attract foreign capital through a more attractive oil law. The old code of June 20, 1921, was practically inoperative since most of the country had been declared a national reserve since 1937.

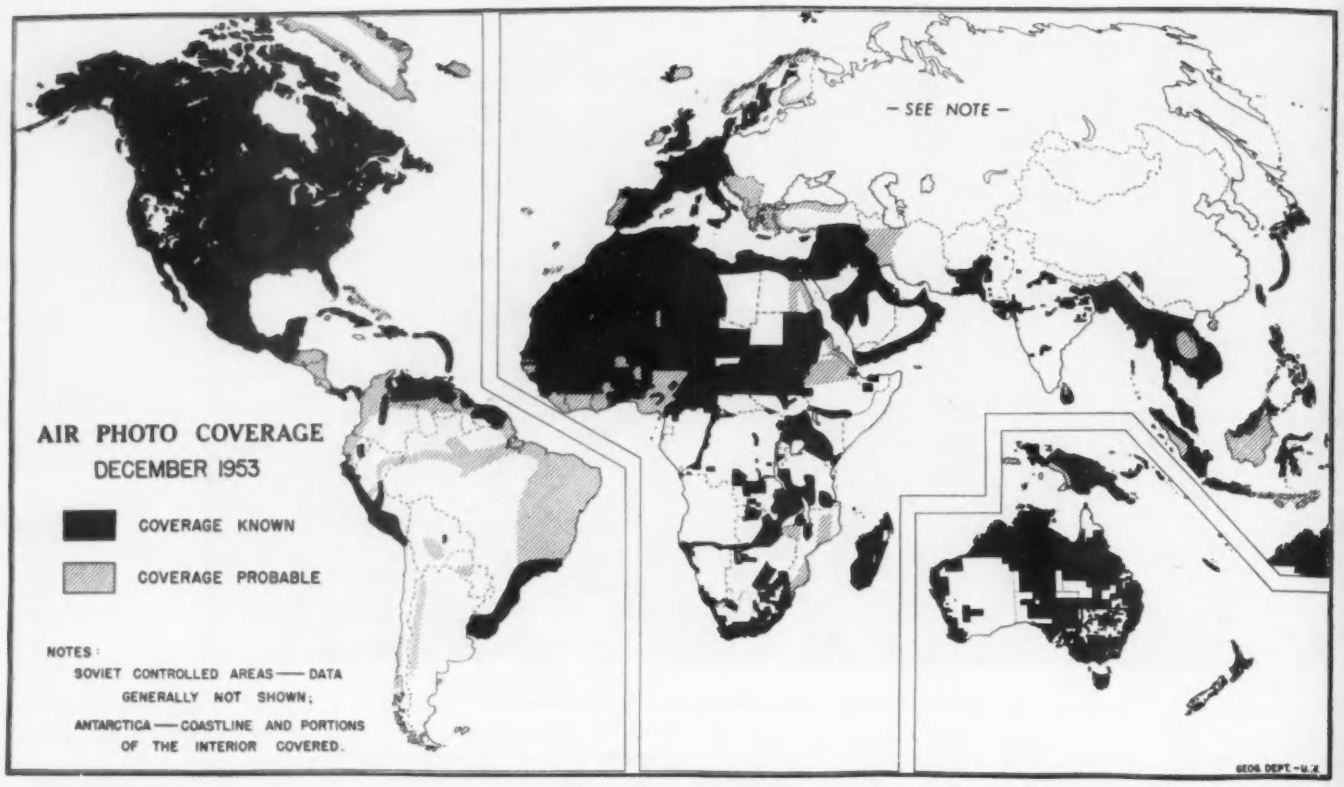
As a result of this suggestion, a contract was signed with a New York firm to draft a modern petroleum code. From the beginning, the project had the full support of President Paz Estenssoro, who pushed it energetically over all obstacles until the final decree was issued Oct. 26, 1955.

Whether this new law will attract foreign capital is the current question in Bolivia. Politically and economically, the situation in Bolivia is far from bright. Yet, the present government already has lasted longer than many of its predecessors. That is an accomplishment in itself. Committed to the economic integration of the Indian, who for many centuries lived on an agricultural subsistence, the government has effected drastic social changes which elicited solid support from the masses.

Although the government is painfully aware of Bolivia's record of expropriation, it hopes to live down its reputation. Recently, an agreement was made with the U. S. to institute an investment guarantee program to encourage private American capital.

Present plans call for general elections early in 1956. If all goes well and as soon as a constitutional government is established, it is intended to push the decree into a law to offer private capital a more solid basis of operation. From then on, operations will depend on the international petroleum industry which may become further interested in increasing its reserves in the Western Hemisphere.

—The End


– SEE NOTE –
AIR PHOTO COVERAGE
DECEMBER 1953
COVERAGE KNOWN
COVERAGE PROBABLE
NOTES:
SOVIET CONTROLLED AREAS — DATA GENERALLY NOT SHOWN;
ANTARCTICA — COASTLINE AND PORTIONS OF THE INTERIOR COVERED.
GEOG. DEPT. - U. W.

Reprinted courtesy Prof. Kirk Stone, Department of Geology, University of Wisconsin.

FIGURE 1

Photogeology Permits Rapid Mapping of Wide Areas

More than a million square miles of earth's surface covered in 1955 by this widely-used exploration tool.

By LAURENCE BRUNDALL
Geophoto Services, Denver, Colorado

PHOTOGEOLOGY HAS become a widely-used method of exploration in the petroleum industry. It is estimated that over a million square miles of the earth's surface was mapped by photogeologic methods in 1955 by a relatively small number of geologists working as consultants or for various companies and government agencies.

There are several established uses of photogeology:

It provides regional coverage in areas in which geologic maps are lacking, or are of unsuitable detail or scale.

It provides leads for further exploration by more detailed surface, subsurface, or geophysical methods.

It provides a ready geologic map reference for quick decisions on submittals.

It provides information for decisions and disposition of lease or concession blocks, that is, whether blocks are to be dropped or whether more detailed work by other methods is warranted.

Photogeology, as a means of exploration, usually is not complete in itself, but, like any other method of exploration, it is an economical aid. It is the ideal approach for preliminary exploration in any area considered to be possibly productive. Photogeology serves to point the way for other methods of exploration; at comparatively low cost it provides structural leads which may be further explored.

Use of photogeology is not restricted to reconnaissance or regional surveys. In many instances, it is desirable to carry out, through use of large scale photography, detailed studies of favorable localities selected from the regional evaluations. The larger scale photography provides proportionately more information so that problems of structure and stratigraphy may be studied in greater detail.

Although the original development

of photogeology was in areas abroad, accent since World War II has been in evaluation of areas in the U. S. It is in this country that photogeologic methods have been developed to a high degree of efficiency. However, in the past few years, with relief of international tensions and more favorable operating opportunities in foreign petroleum exploration and development, photogeologic evaluation is playing an ever-increasing role in this program.

Photography. Since photogeologic evaluation must begin with a set of air photographs, it is desirable to discuss the common types of photography available for foreign areas. As would be expected, amount and type of coverage abroad is less satisfactory than for U. S. coverage. (See Figure 1.)

One of the most common types of foreign photography is trimetrogon coverage, most of which was flown by the U. S. Air Force during and immediately following World War II. About the only factor in favor of trimetrogon coverage for photogeologic evaluation is that it is available over large portions of the earth where more suitable coverage is lacking.

Figure 2 shows the trimetrogon system of photography. The airplane is equipped with three cameras having lenses of 6-inch focal length. One camera is mounted in the vertical position and the other two are mounted as left and right obliques with the camera axes inclined at an angle of 60 degrees from the vertical. By this method, a rapid complete photographic coverage of a large area may be obtained with vertical runs widely spaced and the intervening areas covered by the oblique runs.

Most trimetrogon photography has been flown from a height of 20,000 feet, thus producing a scale of 1/40,000 for vertical photographs. Scale of the oblique photographs is variable, ranging from 1/40,000 along the common overlap with the vertical run to extremely small scales in the far distant oblique portions. Only those portions of the oblique runs as far out as the approximate photo centers are suitable for photogeologic evaluation.

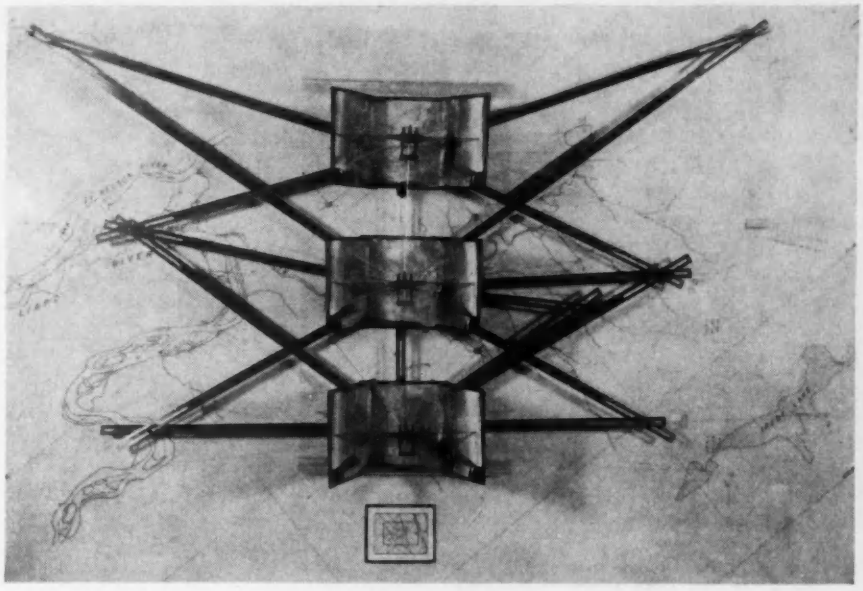


Photo Courtesy U. S. Geological Survey

FIGURE 2—Trimetrogon compilation model. The projecting rays are control points on oblique photographs.

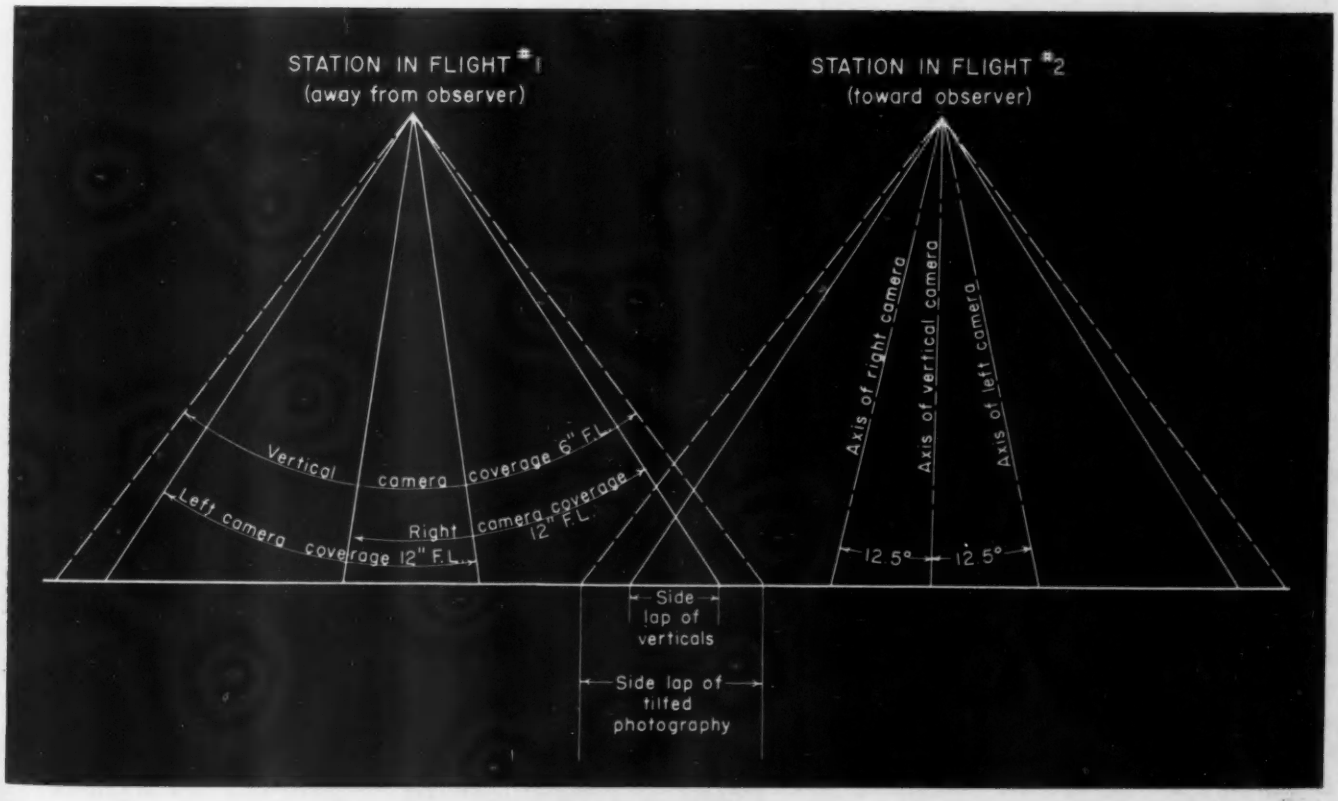
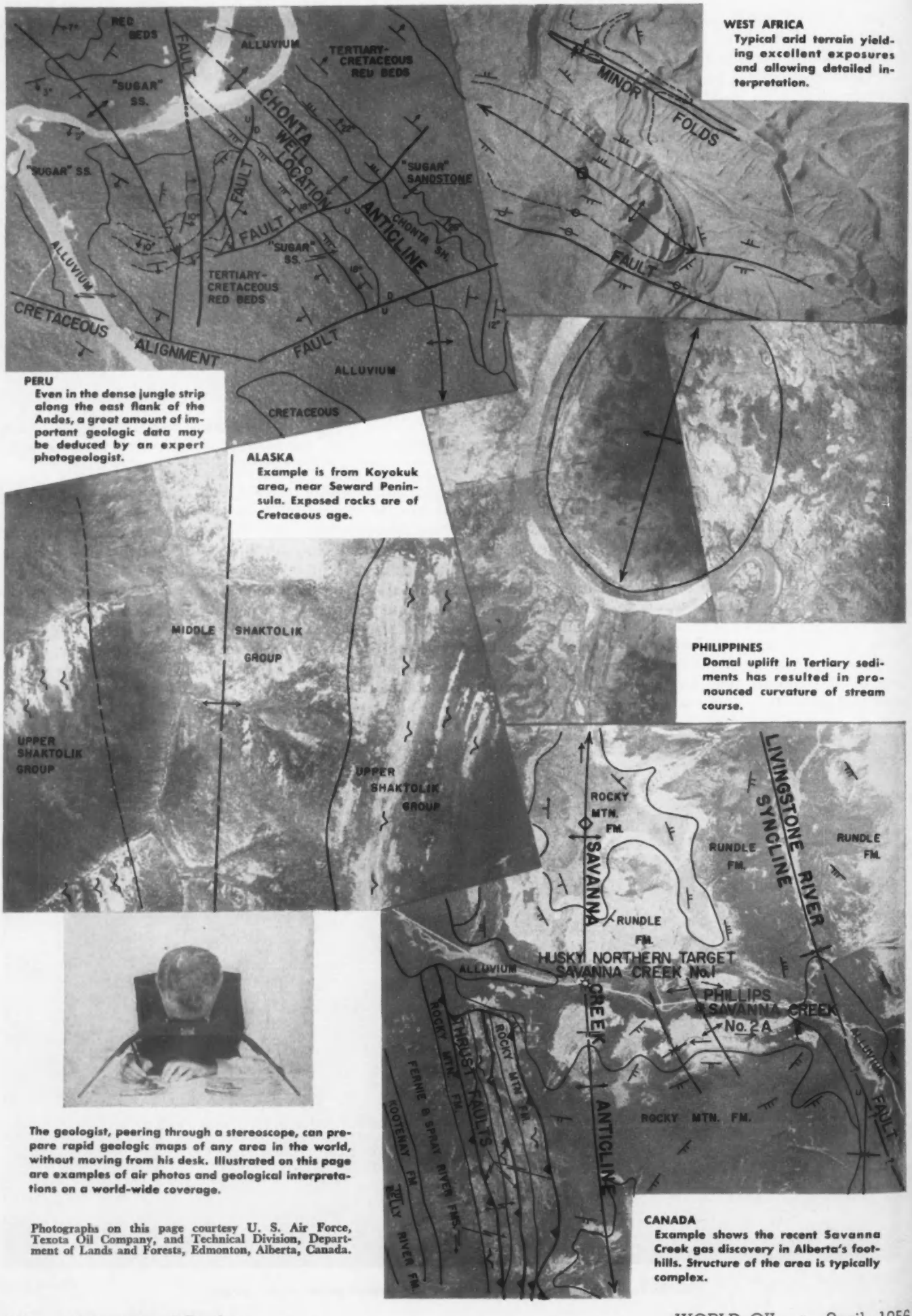


FIGURE 3—Diagrammatic representation of split-vertical system of photography.



WEST AFRICA
Typical arid terrain yielding excellent exposures and allowing detailed interpretation.

PERU
Even in the dense jungle strip along the east flank of the Andes, a great amount of important geologic data may be deduced by an expert photogeologist.

ALASKA
Example is from Koyokuk area, near Seward Peninsula. Exposed rocks are of Cretaceous age.

PHILIPPINES
Domal uplift in Tertiary sediments has resulted in pronounced curvature of stream course.

The geologist, peering through a stereoscope, can prepare rapid geologic maps of any area in the world, without moving from his desk. Illustrated on this page are examples of air photos and geological interpretations on a world-wide coverage.

Photographs on this page courtesy U. S. Air Force, Texota Oil Company, and Technical Division, Department of Lands and Forests, Edmonton, Alberta, Canada.

CANADA
Example shows the recent Savanna Creek gas discovery in Alberta's foothills. Structure of the area is typically complex.

Evaluation of trimetrogon photography can produce results with fair detail along the vertical runs and progressively diminishing detail into the oblique portions. This evaluation is extremely rapid and can be accomplished at low cost. Information it provides is more of a regional type which can be used for planning more detailed surveys.

One of the biggest drawbacks to trimetrogon photography is that the procedure of transferring the geographic, cultural and geologic data on the oblique photographs to planimetrically accurate base maps is complicated and expensive. However, where suitable planimetric maps are available in an area, oblique portions of the trimetrogon photography can be posted to these planimetric maps by a sketchmaster-type plotting instrument. In some cases, prints of the original manuscript trimetrogon sheets are available from U. S. Government sources, and here the compilation process is much simplified since these manuscript sheets show all original photo centers and enough planimetry to control the posting process.

Full vertical coverage of areas abroad is much more restricted than trimetrogon coverage. In some countries outside the U. S., especially in South America, oil companies have underwritten vertical photographic programs on a cooperative basis. This coverage usually is restricted to the underwriting group. Full vertical coverage is available for some areas through the U. S. Air Force, Washington, D. C. In some countries, the national or provincial government has obtained full vertical coverage which can be purchased. In most cases the scale of this vertical coverage is comparatively small (averaging 1/40,000) and, although an evaluation of a full vertical coverage will yield much greater detail than an evaluation of trimetrogon coverage in the same area, detailed photogeologic work in selected areas would require larger scale photography.

Another type of photography used in work outside the U. S. is the split vertical system. In some respects this is similar to the trimetrogon photography in that a vertical camera and left and right oblique cameras are used. However, the vertical camera is equipped with a 6-inch focal length lens which, at the usual flying height above the ground of 30,000 feet, produces vertical photographs at a scale of 1/60,000 (approximately one inch equals one mile). The oblique cameras are at a 12 degree angle from the vertical as compared to the 60 degree angle of the trimetrogon system.

Oblique cameras are equipped with 12-inch focal length lens so the near portion of the oblique coverage is at a scale of 1/30,000. (See Figure 3.) Another difference between the two systems is that full vertical coverage at the 1/60,000 scale is afforded in addition to full coverage of the 12 degree obliques. By a rectification process it is possible to convert the 12 degree oblique photographs into verticals.

Advantage of the twinplex photography is that the 1/60,000 coverage is ideal for mosaic construction and also can be used for regional photogeologic evaluation which yields a much greater amount of detail than evaluation of the oblique portions of trimetrogon coverage. The rectified oblique photographs at a scale of 1/30,000 can be used for more detailed evaluation of favorable areas.

About the Author

LAURENCE BRUNDALL studied geology at the University of Melbourne, Australia, and the University of Chicago, where he obtained a degree in 1935. After graduate work, he worked as an exploration geologist seven years in the Texas-Gulf Coast area before entering the U. S. Navy as a photographic intelligence officer.

In 1945, with three partners, he founded Geophoto Services, with headquarters in Denver, Colo. The firm now has a staff of more than 100. Other Geophoto companies are located in Canada and field offices currently are operative in East Africa and the Far East.

Base Maps. Another important consideration in photogeologic evaluation abroad is type of base map material available. Mapping procedures are simplified greatly with a corresponding decrease in cost and time of operation in areas covered by suitable base maps. The USAF catalog of aeronautical charts published by the Aeronautical Chart Information Center, St. Louis, Mo., is a valuable foreign map reference. World aeronautical charts at a scale of 1/1,000,000 are available for all continental and large island land areas of the world.

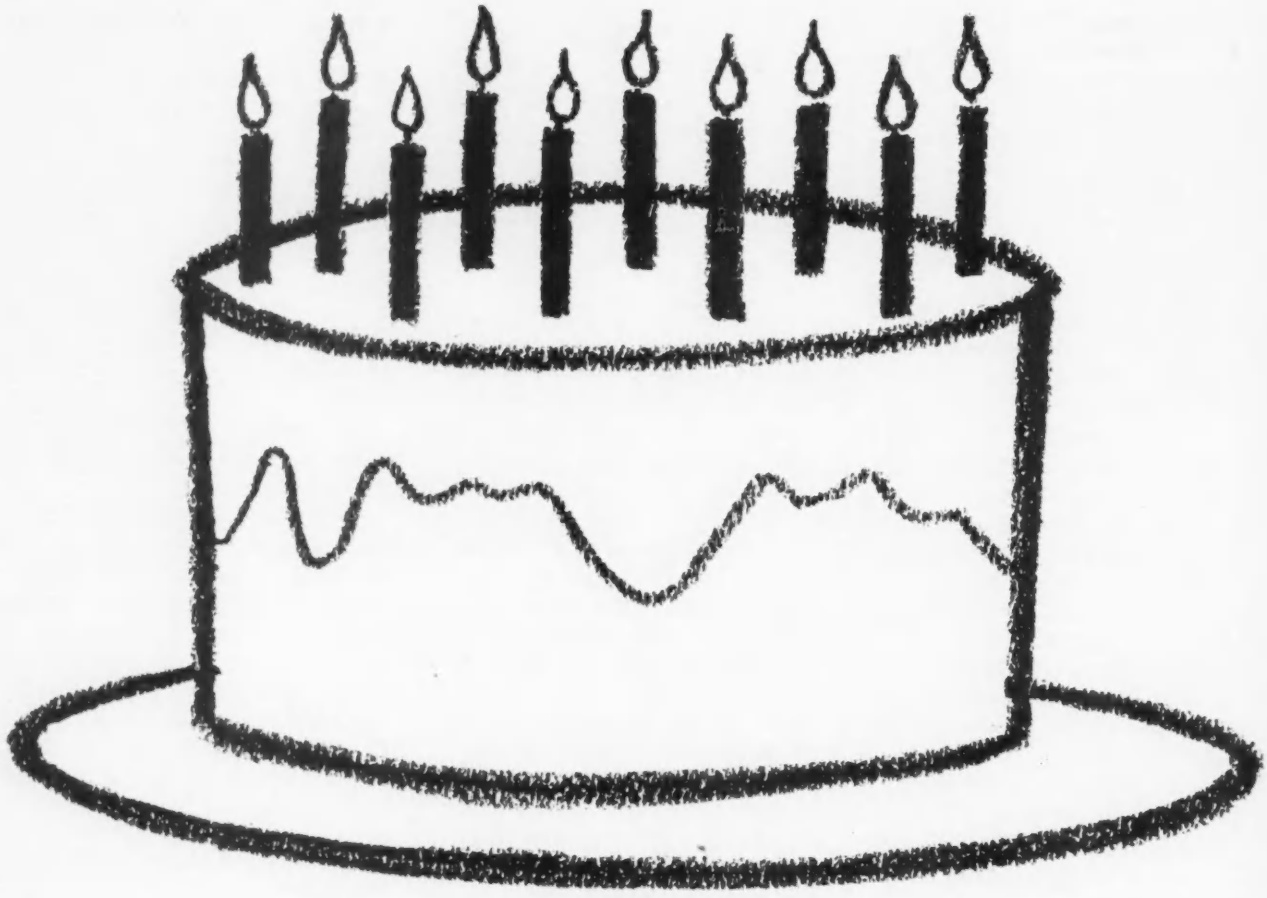
In addition, USAF preliminary bases at scales of 1/250,000 and 1/500,000 are available in more restricted areas, mainly Mexico, Central America, north and west coasts of South America, west coast of Africa, a portion of Libya, portions of east Africa, Arabia, and a few scattered other localities. USAF pilotage charts at a scale of 1/500,000 are available for most of Europe, the Far East, Alaska, and portions of north Africa and Near East. Another type of map available in many parts of the world is the USAF aeronautical approach charts at a scale of 1/250,000.

For areas in Central and South America where suitable larger scale map coverage is lacking, the 1/1,000,000 scale maps published by the American Geographical Society are recommended.

In addition to these map sources, some national or provincial foreign governments have sporadic coverage. Certain British colonies are covered by British War Office maps which are similar to the USAF maps.

Objectives and Working Procedures. Primary objective in photogeologic evaluation abroad is rapid large area regional mapping. This can be applied to evaluation of concessions already granted or as a first-phase operation, followed by some spot field check work, in applying for concessions. Since areas assigned for this type of work usually have a minimum of existing geologic information, the photogeologist is required to be more experienced than for evaluation of areas in the U. S. where usually much more basic geologic information is available, especially in stratigraphic delineation.

Much exploration outside the U. S.



NOW WE ARE TEN- In 1946, only six people celebrated our first birthday. But now that we're ten, we'll count more than 100 noses around the birthday cake.

Growth like ours didn't just happen. Clients made it possible -- clients who put our ever-widening fund of photogeologic experience and judgment to work for them.

So to you, our world-wide clients, we gratefully say: Thank you very much for a wonderful birthday party.

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is concerned with jungle-type areas of dense vegetative cover. It is in such areas that the greatest interpretative skill of the photogeologist is required since many thousands of square miles often are mapped without the photogeologist directly observing a single rock outcrop on the air photographs. However, even in these extremely difficult areas, much important geologic data can be derived from an expert photogeologic evaluation.

Although concealed by vegetation, general character of outcropping rocks often may be deduced from their topographic expression and associated drainage characteristics.

For example, limestone terranes in tropical countries often exhibit a pronounced pitted appearance on air photographs. Where resistant beds occur in the section and dip of the surface rocks is at least moderate, an experienced photogeologist is able to interpret the dip and strike from a study of the topographic expression as exhibited on the tree-top surface. Curved ridge and valley alignments may be reflections of rock units which have been subjected to structural deformation and are an aid to regional evaluation.

Another method of photogeologic evaluation, widely used in the U. S. and becoming more important in evaluation outside the U. S., is geomorphic interpretation of low-relief areas in which regional dip is low. (See Figure 4). Best example of this type of terrain in the U. S. is the Gulf Coastal Plain.

Structural features in such areas often are indicated by one or a combination of geomorphic criteria. Such factors as drainage patterns, stream alignments, marked tonal or vegetative changes, displacement of natural levees, and anomalous widening or constriction of stream courses, can be used as clues to structural anomalies.

Following are some brief comments on photogeologic evaluation in some "hot" areas outside the U. S.:

Libya. Covered by trimetrogon photography. A 100-mile coastal strip also is covered by split-vertical photography. Before purchase of U. S. Air Force coverage in foreign areas can be authorized, diplomatic clearance must be obtained from the government of the country in question. Typical desert terrain yielding a considerable amount of geologic data.

U. S. Air Force Photo

FIGURE 4—Portion of trimetrogon oblique, West Africa, showing an excellent example of geomorphic anomaly. The pronounced semi-oval drainage pattern probably is caused by a domal uplift.

East Africa. Some trimetrogon and vertical British coverage. Geologic expression similar to Libya.

Australia. Large areas covered by Australian government full-vertical photography. Northern and western Australia is mainly arid. Yields excellent geologic data.

Peten Region, Guatemala. Incompletely covered by trimetrogon photography and by private vertical photography. Mainly jungle but photogeology can provide rapid regional structural evaluation.

Montana of Peru. Main areas of current interest covered by Peruvian government photography. Dense jungle terrain; however, careful work in foothills belt can provide satisfactory regional-type information.

Alaska. Complete trimetrogon coverage, also a considerable amount of U. S. Government vertical coverage. Geologic structure commonly complex.

Canada. Almost completely covered by dominion and provincial verticals. Photogeology makes regional studies of the foothills and mountains economically feasible. Search may either be for individual structures or for generally favorable areas. Many of the individual structures of the foothills belt are not always important in themselves, but over-all patterns may be important. Large areas of the interior plains are suitable for geomorphic interpretation.

Summary. Photogeology as applied to petroleum exploration outside the U. S. provides an economically feasible method for mapping large areas of the earth's surface. Such broad mapping programs are necessary in all long range exploration. Initial purpose of photogeologic evaluation may be fulfilled in a relatively short time, but information obtained, apart from its immediate value, will be useful in future years when it is reviewed from time to time in light of new discoveries and added geologic data.

—The End

FIGURE 1

Oil Exploration by Valdebro in Spain

Long-range joint Spanish-American venture to drill 4-6 wells yearly.

By JUAN GAVALA
President, Comisión de Investigaciones, Petrolíferas Valdebro

and EARLE F. TAYLOR
Senior Vice President, DeGolyer and MacNaughton, Dallas

THREE WELLS have been drilled and a fourth is drilling—that is the record of the Comisión de Investigaciones Petrolíferas Valdebro's search for oil and gas in Spain. The program was begun in 1952, and geological reconnaissance of the sedimentary areas has been completed. Detailed geological studies are progressing.

Gravity work was begun in February, 1954, and is continuing in various areas. Seismic surveys started in November, 1952, and two crews are in operation now. Plans call for the continuance of this ample program and include the addition of another drilling rig this year. This joint Spanish-American operation is proceeding smoothly and efficiently toward a full evaluation of Spanish oil and gas potentialities.

This article is concerned primarily with the petroleum operations conducted in Spain by the Comisión de Investigaciones Petrolíferas Valdebro (Valdebro Commission for Petroliferous Investigations) usually referred to as "Valdebro." It is not intended as an historical review of petroleum in Spain nor as a comprehensive study of current developments in this country, other than those of Valdebro. Since 1952, the oil exploration effort

conducted by Valdebro has been a major part of the overall search for petroleum and gas in Spain. It is this program which will be described.

Origin and History of Valdebro. Valdebro was constituted in Madrid on July 26, 1952, between the Instituto Nacional de Industria (National Institute of Industry) and an American group headed by General American Oil Company of Dallas, Texas. The Valdebro group was organized for the purpose of exploring for oil and gas in Spain in areas not under concession at the time of organization. If oil is discovered and if it is convenient, the group will continue a development program of the mineral resources in the discovery area.

During the exploration period, it is agreed that participation and rights of the National Institute of Industry and the American group will be to the extent of 50 percent for each of them. November, 1954, saw the beginning of a new five-year agreement to carry out this exploration program. On termination of the agreement, all assets of the joint organization will be distributed equally.

First concessions were taken out by the group in the valley of Ebro river and were referred to as the "Milagro Concessions." Subsequent concessions were taken in the Castilfrio area north of the town of Soria, in the sedimentary basin east of the town of Cuenca and in the Burgos area. Stratigraphic tests were drilled on the Milagro and Castilfrio concessions, and a deep test has been completed in the Cuenca area. A fourth test is drilling near Burgos in northern Spain (see Figure 1).

The Valdebro agreement has been in effect since the original signature on July 26, 1952. It has worked successfully toward an evaluation of oil and gas possibilities in Spain. The group is directed and managed by a managing commission composed of five members—two appointed by the American group and three by the National Institute of Industry. Sr. Juan Gavala, appointed by NII, has served as president of the commission since its inception.

From the beginning of operations by Valdebro, certain technical studies relative to geology, geophysical and drilling programs have been carried out by DeGolyer and MacNaughton under direction of the commission. Gravity studies began in February, 1954, and are being carried out by the Geophysical section of the Instituto Geologico of Spain. Drilling operations, which began in March, 1953, and are continuing at the present time, have been supervised by Delta Drilling Company of Tyler, Texas, under the direction of the Valdebro commission.

Seismic operations began in the Ebro valley during 1952. Two crews are now operating. The Valdebro organization under Sr. Gavala's direction has operated efficiently to the satisfaction of both the Spanish government and the American group.

Plans call for a continuation of geological, geophysical and drilling programs. Whereas technical studies have been primarily concentrated on geological reconnaissance during the past two years, emphasis is gradually shifting to seismic and drilling operations and some geological detailing of potential drilling sites. Present plans include addition of a second drilling rig capable of reaching 10,000 feet. Drilling operations are designed to reach basement or rig capacity so as to fully evaluate subsurface conditions in those sedimentary areas which previously have not been drilled.

Geological Studies. Since geology is basic to a petroleum exploration program, considerable effort has been made by Valdebro to understand thoroughly the geology of Spain, especially the sedimentary basins. To accomplish this, a program was devised to make available all published information and to supplement this with intensive field studies where needed.

The program resolved itself into a two-fold operation:

- Office compilation of all previously published data.
- Field studies, both reconnaissance and detailed.

Office Compilations. A substantial amount of geological information on Spain has been published in Spanish, English, German, and French. Assembling these data and reducing them to some usable form was a major task, requiring about two years. From the data, cross-sections were prepared, columnar sections were constructed for various basins, well logs and descriptions were assembled, and the geological history of the country was compiled gradually.

Many maps of varying scales were accumulated during this study. Of importance is the "Mapa Geologico de España y Portugal" published by the Instituto Geologico y Minero de España. This map is on a scale of 1:1,000,000, and was prepared by Ings. D. Antonio Almela, D. Jose Maria Rios, and D. Carlos Muñoz under the direction of Sr. D. Jose Garcia Siñeriz. Now available is the third edition, published in 1952. Also of inestimable value are the various hojas, or bulletins, covering the geology and topography of specific areas. More than 160 of these have been published by the Geological and Mining Institute.

A final result of the office compilation work is a set of maps on a scale of 1:200,000 covering all the sedimentary areas of Spain. Each set of maps includes a geographic base, an areal geology overlay and a general data overlay showing structural features, all known indications of oil and gas and all known concession boundaries. For use in comprehensive reports, these 1:200,000 scale maps have been reduced to a scale of 1:500,000 to provide a map of the entire country in two sheets. As field studies progress, new information is added to these maps.

Field Studies. Geological reconnaissance of most sedimentary areas has been completed. Begun in 1952, this work was greatly intensified by Valdebro in 1953. Field work has been carried out by Spanish and American geological field parties. The number of field parties operating at any one time has varied from one to five.

In areas of primary interest, detailed geological studies were undertaken where surface conditions made this feasible. Topographic sheets and air photos were utilized wherever possible. For each area studied, a report, geological map and cross-sections were prepared.

Spain's sedimentary geology is complex, due largely to thrust faulting present throughout a large part of the country. A thick sedimentary section from basal Triassic through Miocene is of interest in the search for petroleum. Part of the section is marine in

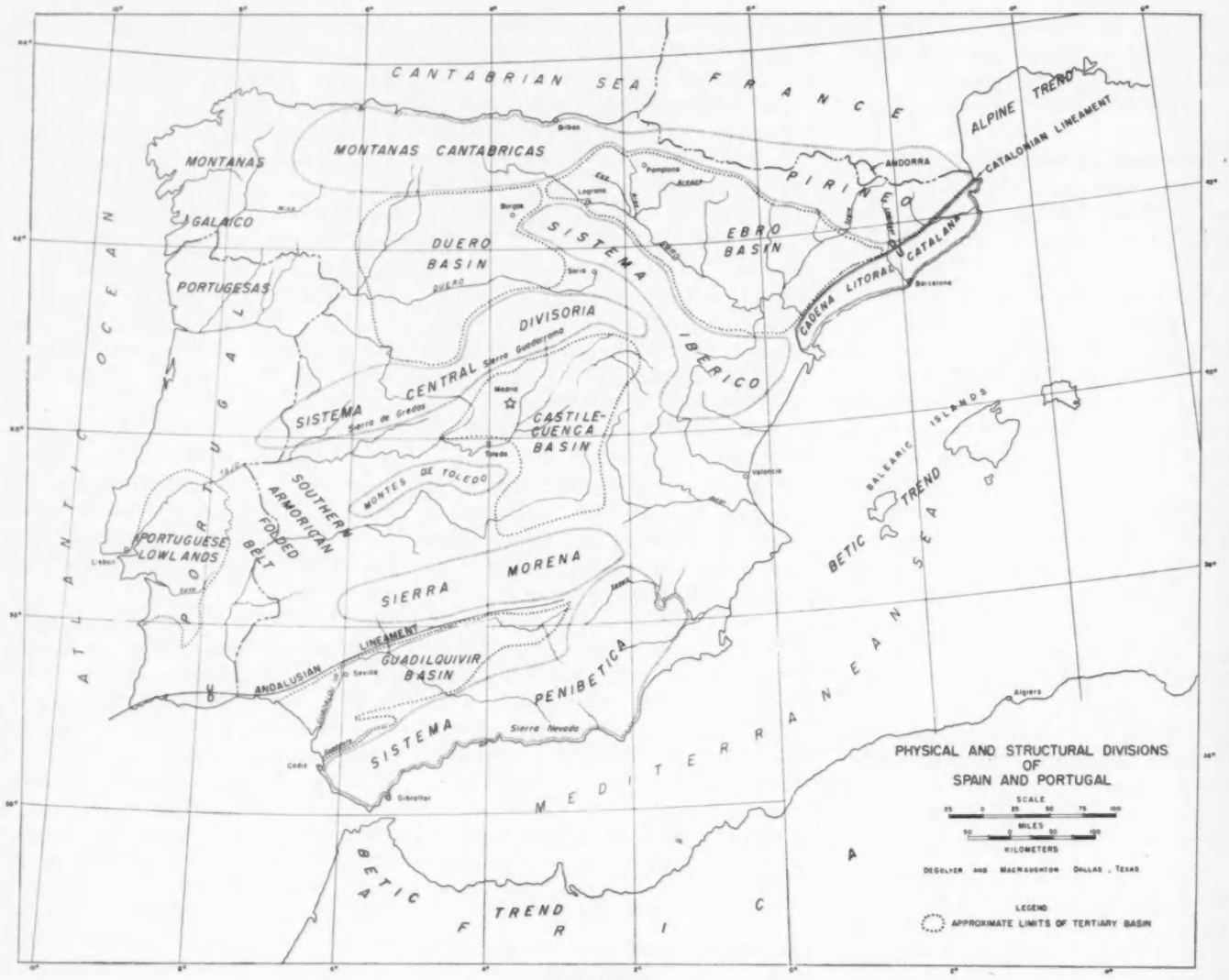


FIGURE 2

origin. Thick evaporites exist in the Oligocene and in the Triassic.

Indications of hydrocarbons are known from many outcrops and from a number of wells. There are many good exposures of sedimentary rocks in Spain, but the complex faulting, coupled with the fact that Oligocene and Miocene sediments cover extensive areas of the surface, makes interpretation of the sedimentary geology difficult in some areas.

Geophysical Operations. Geophysical work has been a part of the Valdebro exploration program almost from the start. Seismic surveys were initiated in November, 1952. Since then, geophysical operations have been nearly continuous. Both seismic and gravity programs are now in progress.

First seismic work undertaken for Valdebro began on the Falces anticline in the Ebro valley in November, 1952. This program was undertaken to examine the subsurface structure on the prominent Falces anticline on which the Marcilla 1 well was located.

Considerable difficulties were encountered at the start due to the presence of gypsum at many places on the surface. The work was gradually extended to the Tafalla anticline north of Falces and later to the Puente de la Reina area. This program was concluded in August, 1953.

One reflection crew began seismic work in Spain in December, 1954. Surveys began in a sedimentary area of Old Castile which is drained by the Duero river (see Figure 2). Headquarters were established at Burgos. The program was undertaken to supplement geological studies west of Soria which indicated the presence of Mesozoic anticlinal trends plunging to the northwest under the Tertiary sediments south of Burgos. These trends were readily located by the seismograph and a program was initiated to outline a drillable structural closure.

In May, 1955, a second crew was added to the Valdebro program in Spain. This crew also established temporary headquarters in Burgos and organized personnel and equipment before transferring to the Cuenca area. Seismic profiles were completed across the San Lorenzo, Villanueva and Cerro Morro anticlines. In most cases, good to fair reflections were obtained. Most lines indicated complex subsurface structural conditions.

One seismic crew continued working from the Burgos headquarters, but the second crew transferred from Cuenca to Jerez de la Frontera, in southern Spain, in July, 1955. The seismic program in southern Spain has two main objectives:

- Check mapped gravity anomalies.
- Outline one or more drilling sites.

Since the program has just begun, it is too early to predict results. Good reflections have been obtained in some of the experimental lines, so it is thought that the original objectives will be completed successfully.

A program of gravity surveys was

begun in southern Spain in February, 1954. This work was undertaken by an all-Spanish crew of the Geophysical Section of Instituto Geologico y Minero of Spain. Gravity work began in the Guadalquivir basin area of southern Spain. A considerable area was mapped before gravity studies were terminated in this basin in April, 1955. Interpretation of the gravity data checked well with predictions made on the basis of surface geological information in this region. It is hoped that subsequent checking by seismograph may substantiate the gravity to the extent that it can be utilized in localizing drilling sites in this region.

From the Guadalquivir basin, the gravity work was moved to Zaragoza in northcentral Spain. Surface geological studies on the north side of the Iberica mountains suggested the existence of certain Mesozoic structural features which might continue northward toward the Ebro valley.

Such features, if present, are hidden beneath Tertiary formations and before embarking on a seismic program, it was decided to carry out a gravity survey.

Preliminary field work has been completed but maps, and final interpretation of this work will not be available for some months. In the meantime, the gravity operations have been transferred to southern Spain for additional reconnaissance.

Drilling Operations. Three holes—Marcilla 1, Castilfrio 1 and San Lorenzo 1—have been drilled. A fourth well, Iglesias 1, is now drilling.

• **Marcilla 1**—The Marcilla 1 well, located in Navarra Province, was spudded March 17, 1953, and abandoned as a dry hole June 27, 1953, at a total depth of 11,205 feet. The well was drilled with a rig capable of drilling to 14,000 feet.

Below a thin veneer of surface alluvium, the hole encountered sediments of Oligocene age and remained in these sediments to total depth. Ditch samples were taken at ten-foot intervals and nine conventional cores were cut starting at 4691 feet. From the surface to a depth of 9708 feet, the formations consist of gypsum and anhydrite interbedded with varying quantities of salt and grey shale. Below 9708 feet, the sediments are red shale and siltstone with minor quantities of gypsum.

An electric log was obtained to 10,000 feet and a Gamma-ray log to 11,192 feet. The self-potential device did not provide a useful curve. It recorded only a slightly irregular line to 9700 feet with somewhat more definition below this depth. Little useful information was derived from the microlog. The Gamma-ray log was more informative since it clearly differentiated low-activity salt and radioactive shale.

No shows of oil or gas were encountered in this well.

• **Castilfrio 1**—Castilfrio 1, located in Soria Province, was spudded July 5, 1954, and abandoned as a dry hole on Nov. 11, 1954, at a total depth of 7220 feet. The Marcilla 1 rig was used to drill the Castilfrio 1.

Castilfrio 1 achieved its objective, which was to obtain data on the complete stratigraphic section in this area. The well was located on an outcrop of Wealden sandstone near the crest of a closed anticlinal structure mapped by surface geology. The following section was drilled:

0 to 1739 feet—Wealden clastics.
1739 feet to 2854 feet—Jurassic limestone shale and sandstone.
2854 feet to 4757 feet—Liassic limestone and marls.
4757 feet to 5860 feet—Keuper evaporites.
5860 feet to 6535 feet—Bundsandstein clastics.
6535 feet to 7220 feet—Silurian siliceous sandstone.

In addition to cores and samples, an electrical log, microlog, caliper log, gamma-ray log, limestone log, dipmeter survey, and a velocity survey were obtained.

A number of formation tests were completed in this well, but no substantiated shows of oil or gas were observed.

• **San Lorenzo 1**—San Lorenzo 1 well, located in Cuenca province, was spudded Feb. 15, 1955, and abandoned as a dry hole Sept. 10, 1955, at a total depth of 8466 feet. The well was located on a prominent surface anticlinal structure exposing upper Cretaceous (Senonian) limestone. Seismic profiles across the structure indicate the presence of a fold complicated by faulting.

Final correlation of stratigraphic horizons in this well is not complete. Some notes on the first few thousand feet are available:

From 0 to 518 feet—upper Cretaceous limestone.

From 518 feet to 869 feet—lower Cretaceous (Albian) shale and sandstone.

From 820 feet to 3714 feet, the well penetrated Liassic rocks. Below 3714 feet the correlation is not clear at this time, possibly because of faulting.

• **Iglesias 1**—Iglesias 1 well, mentioned briefly above, is located near Burgos in northcentral Spain and is being drilled on a seismic anomaly. Since no deep tests have been drilled in this area, the well is projected to rig capacity or until basement rock is encountered. Drilling began Oct. 25, 1955.

Future Drilling. Valdebro has purchased a second rig for drilling operations in Spain. It is intended that two rigs will be kept in operation for the next several years. Tentatively, the program will be to drill one or more holes in southern Spain with the new rig, and to continue drilling in central and northern Spain with the present equipment. The program contemplates the completion of four to six exploration wells each year.

Summary. The Comisión de Investigaciones Petrolíferas Valdebro, which began operations in September, 1952, is engaged in an all-out effort to determine the oil and gas possibilities of Spain. The most modern geological, geophysical and drilling equipment and techniques are being used by a technical staff of Spanish and American geologists, geophysicists and engineers.

Planning is on a long-range basis since it is mandatory that a considerable amount of surface and subsurface geological data be collected to develop satisfactory test well sites. Emphasis in field operations is shifting from reconnaissance geology to seismic and drilling.

It is too early to comment on the success of the program from the oil finding viewpoint. It can be said, however, that a vast amount of technical data is being utilized in the search for oil. From the point of view of cooperation and harmony in this Spanish-American venture, the program is a complete success and might well serve as a model for operations of this type in other parts of the world. —**The End**

Cold-Weather Pipelining Solves Hot-Weather Problems

STANDARD-VACUUM PETROLEUM COMPANY has solved a pipe line paradox in the hot and humid land of the monsoon. And the solution was heat—the same answer to the same problem Stanvac engineers in Sumatra would have sought out if they were operating in northern Canada's sub-freezing temperatures.

The problem: how to move 105° pour point Lirik oil from Central Sumatra.

The answer: heat the crude to a temperature of 153° F. and reheat it at heater-pump stations every 18 miles up the 88-mile line from Lirik field to the Buatan terminal on the Siak river. A tracing line will carry hot water and steam to "thaw" the 8-inch line after shutdowns.

Lirik crude has been a transportation headache since the field was discovered in 1939. During World War II, the Japanese worked out their own solution. They cooled wicker baskets in the river, filled them with hot oil, allowed it to harden, and then floated the baskets down the Kuantan river lashed together as a large raft.

Stanvac's engineers had considered many possible solutions, except the wicker baskets, but all were ruled out as impractical or uneconomic. Among the suggestions considered were:

1. To blend the crude with naphtha, 35 percent solvent and 65 percent of oil. This was ruled out because of the need for a large diameter pipe line in addition to a topping plant and solvent return line.

2. To emulsify the crude with water. This was ruled out because the oil formed a virtually permanent emulsion which could not be broken commercially.

3. To move the crude through the line in a solid plug floating inside a sleeve of water, to electrically heat the pipe wall, or to use vis-breaking installations. These were impractical or uneconomic.

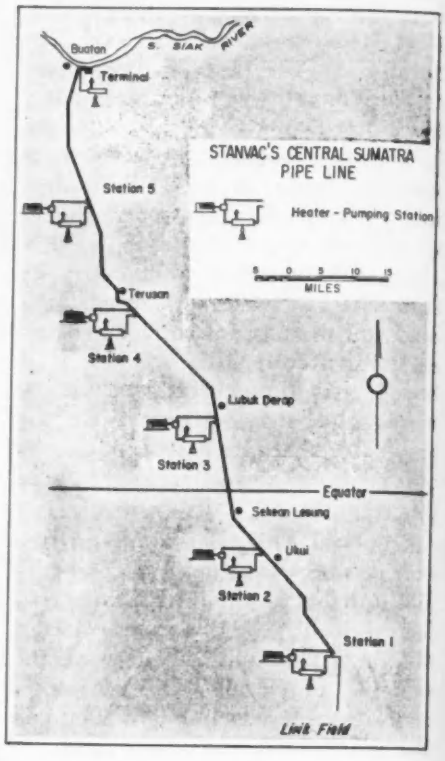
Now, however, to keep the oil moving in the pipe line, the oil will be heated to 153°. Experiments indicate the oil will cool almost to the pour point in about 18 miles of pipe line flow. So four heating units will be installed at pumping stations located at 18-mile intervals along the line to reheat the oil to 153° F. A fifth heating-pumping installation will handle the crude at the Buatan terminal on the Siak river.

When the new pipe line is completed in 1958, 20,000 to 32,000 barrels are scheduled to be moved from the Buatan terminal daily by tanker down the 56-mile waterway to the sea. Now, 2000 barrels of Lirik crude are shipped down the Kuantan river in shallow draft, coil-heated barges to deepwater facilities, and then on to Stanvac's Sungei Gerong refinery in south Sumatra.

Lirik wells flow normally under about 700 psi reservoir pressure. However, when wells are shutin, the high-paraffin crude solidifies in the top 500 feet of the tubing. Hot-water pipes are incorporated into the upper third of the string and in the wellhead. Steam and hot water tracing systems heat all gathering lines.

So it is that Stanvac is overcoming a problem. Despite the transportation difficulties, the low sulfur content and high component yield of Lirik crude during catalytic cracking promise to make the effort worthwhile.

—The End



Mecom Group Acquires Honduras Area; Test Begun

Approximately 50 million acres of Honduras coastline have been acquired by Houston oilman John W. Mecom and others for oil exploration. Extending the entire northern length of Honduras, the property consists of some 14 million acres on land and the balance offshore. The coastline runs east and west. With Mecom in the enterprise is another Houston oilman, Ernest Cockrell, Jr.

The property was acquired from Compania Petroleria Hondurena, S.A., which retains 15 percent of the acreage. The Honduran firm includes a number of Honduras businessmen and a group of Texas oilmen, headed by David C. McCord, of Dallas, and including the estate of the late John Sullivan, San Antonio.

The Honduras company secured the original concession. To validate it, a test in the Mosquito area had to be spudded in by February 3, 1956. It was spudded January 25, projected to 4500 feet. It is presently drilling below 1795 feet.

Mecom said that he would move in some of his drilling rigs, capable of more depth than the Honduras rigs, and would conduct an extensive exploration program.

Union's Costa Rica Well May Be Significant Find

Continuing favorable reports indicate that Union Oil Company of California's Cocoles 1, in Limon Province, Costa Rica, may be a significant discovery. The well encountered a "substantial" thickness of oil saturated limestone at approximately 5400 feet which, on several formation tests, yielded gas and high gravity crude oil. Casing is to be run to protect the zone and the well will be carried deeper to prospect ahead.

The well is the company's fourth test in the Republic of Costa Rica. The location falls in a 3 million-acre exploratory concession in the eastern part of the country.

150 Geophysical Crews Operating in W. Canada

Latest figures show that 150 geophysical crews are searching for oil and gas indications in Western Canada. Peak recorded in 1955 was in December, when 156 crews were reported in the field.

Top-ranking Alberta province records 103 seismograph units and four gravimeter crews, with 26 parties active in second-place British Columbia, 13 in Saskatchewan, and 2 each in Manitoba and Northwest Territories.

It is usual for geophysical operations to be concentrated in the northeast section of British Columbia and northwest regions of Alberta at this time of year due to the large muskeg sections which can be mapped and studied only after the "deep freeze" begins.

Pemex Outlines Program To Increase Production

An expanded program for 1956 will boost production to the highest point since 1938 and slash costly imports, predicts Antonio J. Bermudez, head of Mexico's oil industry.

Terming oil imports the major problem facing Pemex, government-owned oil monopoly, the executive promised that they would be cut in all areas, except in Tiajuana and Mexicali, Baja California, which are still far from Mexico's refineries. The program entails a saving of around $40 million a year.

The first months of the new year definitely will see completion of the ten-project program initiated in 1955, Bermudez said in Mexico. Eight of the projects already have been completed. Floods and hurricane damage were responsible for delays in construction of the remainder. Features of the 1956 program are:

Construction of a new oil city, to be known as Ciudad Pemex, in the zone, El Bayo, adjacent to the José Colomo oil fields of Macuspana, State of Tabasco. A large refinery will be built, and the entire Isthmus of Tehuantepec will be serviced by a pipe line between the new city and Nanchital. Enormous gas reserves promise to make this zone one of the most important in Mexico, the Pemex director said.

Modernization and expansion of the refinery Ciudad Madero will continue. This refinery and the Arbol Grande refinery will "be as good as any in the world," according to Bermudez.

New port facilities will be built in Tampico. Floods and hurricanes seriously damaged present harbor areas.

A major drilling effort will be made in Tabasco, where recent exploration has indicated important, untapped resources.

Two important cracking plants will be built, similar to the installation at Minatitlán. These are to be located in Atzcapotzalco and Salamanca.

Gas producing facilities in Poza Rica will be expanded.

A pipe line between Minatitlán and Salina Cruz will be completed. Tankers at the port terminal will supply Pacific Coast ports, until now dependent on U. S. imports.

New facilities at Poza Rica will raise production of refined products from 4000 to 10,000 barrels.

The new refinery at Reynosa will be expanded.

Union Alberta Discovery Followed By Two Tests

Union Oil Company of California has spudded two widely-spaced follow-up wells on its large block of acreage in the Red Earth area of northern Alberta. This area, experiencing a land-filing rush of large proportions following Union's discovery last month of substantial flowing high gravity production in the Granite Wash formation, may see a number of wildcat wells spudded within the next few months.

Union's discovery well, Red Earth 12-17, located approximately 215 miles north of Edmonton, flowed on test at a rate of 960 barrels daily of 38 gravity crude through a 20/64-inch choke from a depth of 4975 feet. The well presently is shut in pending construction of surface facilities. The discovery is located on a 700,000-acre block. Since making initial tests on the well, the company has acquired an additional 700,000 acres of Crown Reservations.

Union's two follow-up wells, East Red Earth 14-8, located 4½ miles to the northwest, and Loon River, about 19 miles to the northwest, currently are drilling above the objective sand.

Stanvac Acquires 8 Luzon Exploration Concessions

Standard-Vacuum Oil Company has been granted concessions by the Philippine government of 388,350 hectares (966,000 acres) in eight separate grants in the Cagayan valley of Northern Luzon. The concessions are for four years with the right to acquire two three-year extensions. Half of each concession may be converted to oil development grants.

Several of the tracts are contiguous, and there are three distinct blocks of acreage, from north to south, as follows: One along the coast facing the Babuyan channel, east of the Cagayan river; the second being a large Y-shaped block along the Cagayan river, with Tuguegarao located at the apex of the Y; and the third lying between the Cagayan and Magat rivers, upstream from the other two.

Stanvac sent a geological team to work surface beds in this area in October, 1955. In addition, construction of a refinery is planned. A team of Stanvac negotiators, headed by Joseph A. Parrish, regional coordinator for the Far East, has discussed the proposal with the National Economic Council in Manila. Present plans call for a $35 million fuel products refinery with a crude capacity of 21,000 barrels per day. Stanvac has been marketing in the Philippines since 1897.

Reports of Major Strike In Kuwait Confirmed

Kuwait Oil Company has made a major discovery in northern Kuwait in recent months. The firm is owned 50 percent each by Gulf Oil Corporation and The British Petroleum Company Ltd.

The capital stock prospectus of Gulf Oil Corporation, released Feb. 3, 1956, says "An exploratory well, recently completed in the northern part of Kuwait, indicates an important new field has been found."

A Gulf official in Pittsburgh was quoted as saying that the new well is "unquestionably a major discovery" but declined further comment.

The test is reported to have encountered thick oil sands equivalent to the Burgan field pay, and at least equally productive.

a WORLD of OIL

By **DON KLIEWER,** World Oil Staff

ARGENTINA. Reportedly the largest oil producer in Argentina's history, which was brought in at Madrejones field in Salta province late in February, is producing an average of slightly more than 4200 barrels daily.

AFRICA: D'Arcy Shell Petroleum Development Company of Tanganyika, jointly owned by The British Petroleum Company Ltd. and Royal Dutch/Shell, announced recent abandonment of a deep test on the east African island of Mafia at a depth of 11,051 feet. Equipment was being moved to Zanzibar island, 140 miles north, where a second test will be drilled.

CANADA: Sinclair Canada Oil Company, a subsidiary of Sinclair Oil & Gas Company, has its first Pembina field production with the completion of Well 16-24 Blue Rapids B, which flowed 271 barrels of oil in 16 hours from Cardium sand at 5476 feet . . . Saskatchewan's first discovery of 1956 was a light gravity discovery by Imperial Oil Limited in the Cantal district of southeastern Saskatchewan, 5½ miles from the town of Cantal and 5½ miles southwest of Alida oil field. When the pipe was pulled after the initial drillstem test of the Mission Canyon, it contained 300 feet of 42-gravity oil, and gas flowed to the surface at a rate of 360,000 cubic feet daily . . . C. and E. Harmattan Oil Operators report an indicated Mississippian discovery in Alberta six miles south of Westward Ho field with production of 188 barrels of 36-gravity oil per hour from 9165-9180 feet.

EGYPT: Sahara Petroleum Company, a subsidiary of Continental Oil Company, will drill a wildcat midway between Alexandria and Cairo. The well, 1 Wadi Natrun, will be Sahara's second test in Egypt . . . Sahara's first wildcat, located 28 miles southwest of Alexandria, was drilling ahead at 10,300 feet without any commercial oil shows.

FRANCE: Societe des Petroles de Valence, 30 percent owned by The British Petroleum Company's subsidiary, D'Arcy Exploration Company, received an exploration license in the Isere Department, on the western edge of the Alps. An additional 20 percent of the new company is owned by BP's French associate, Societe Francaise des Petroles BP.

GERMANY: Total footage drilled during 1955 amounted to 2,408,416 feet, as compared to 2,158,041 feet in 1954. . . . Daily average crude production in January, 1956, amounted to 63,915 barrels, while the daily average during 1955 was 61,220 barrels.

INDIA: Assam Oil Company, Ltd., was scheduled to spud in Moran 1 well at Moran in the Assam valley which will be drilled to 12,000 feet as part of Assam Oil's opening of a new exploration operation.

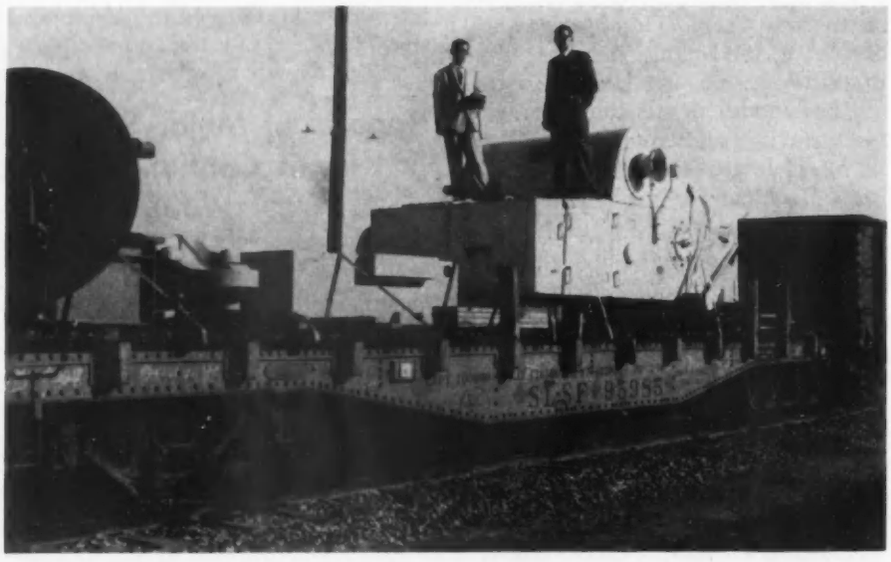
IRAN: National Iranian Oil Company January 1 assumed responsibility for medical and health services in the oil fields of south Iran that previously were under the Consortium, including nine hospitals and 39 clinics employing more than 2000.

NETHERLANDS: International Drilling Company N. V. was organized recently for a three-year drilling program, with six wells to be drilled under contract with Royal Dutch/Shell and The British Petroleum Company.

PERU: International Petroleum Company reported that gross crude production increased to 109,500 barrels daily for a 4 percent rise in 1955 over 1954. Company output averaged 31,000 barrels daily in Peru and 78,500 barrels daily in Venezuela.

SAUDI ARABIA: Arabian American Oil Company production during December, 1955, amounted to an average of 1,028,216 barrels per calendar day, with total output for the year reported at 352,239,912 barrels, or an average of 965,041 barrels daily.

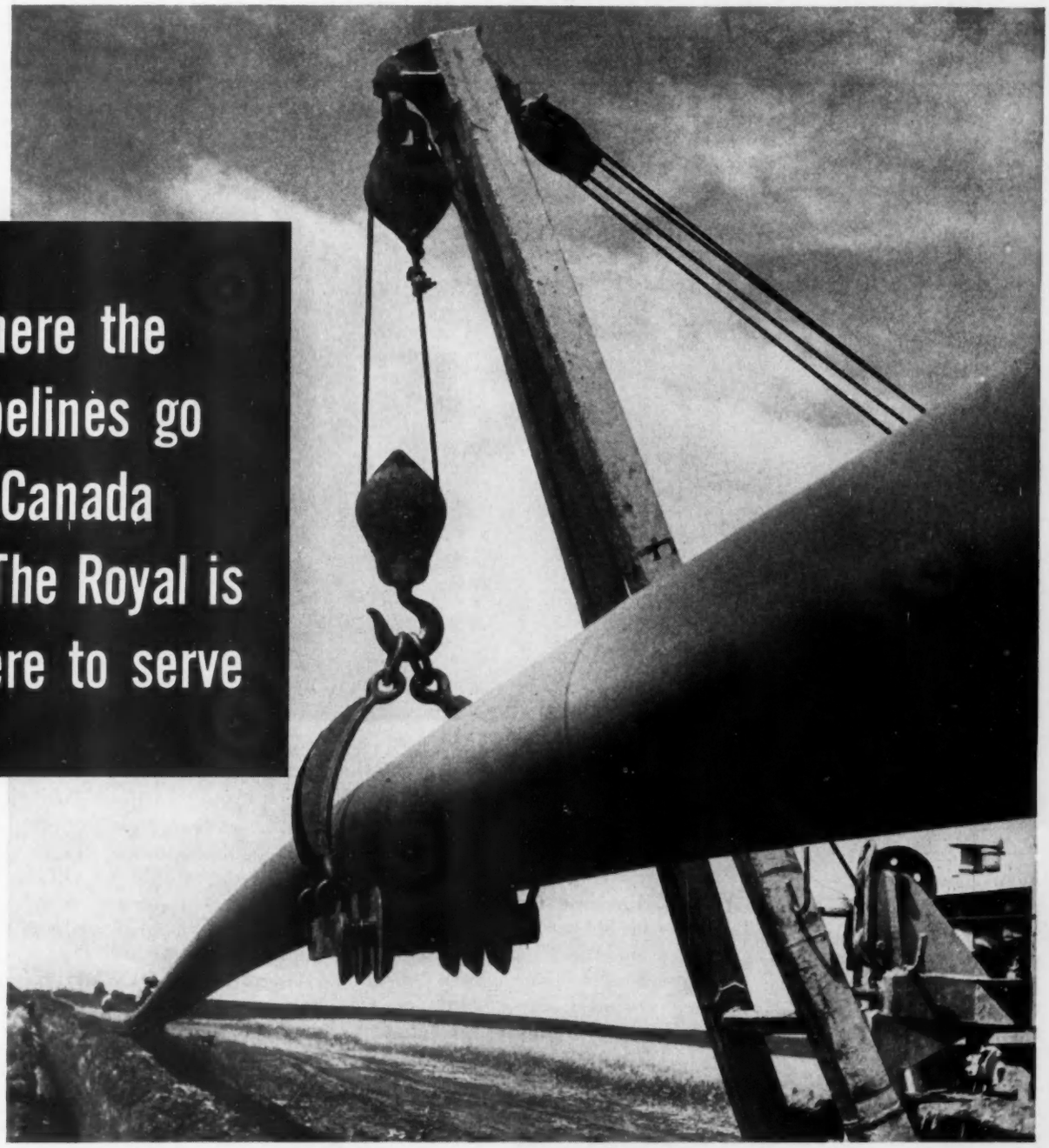
VENEZUELA: Italian firms of Fiat and Innocenti have signed an agreement to build a $173 million steel plant in the Orinoco valley . . . Government officials in December dedicated a research center in Caracas for analyzing domestic minerals for commercial development and for training personnel for a future petrochemical industry. The new institution also will include a natural gas department.



—Photo courtesy Cuba Petroleum News Digest and Gene Carrier.

Simpson Begins Cuban Operations

C. J. Simpson Drilling Company, Dallas, Texas, has imported one of the largest rotary rigs ever used in Cuba, a unit equipped to drill to 14,000 feet with 4½-inch drill pipe. Shown standing on the drawworks are Jake Wagstaff, left, Simpson operations manager in Cuba, and Gordon Wright, a representative of the Simpson Dallas office. Fourteen carloads of equipment arrived in Havana on February 23, cleared customs, and moved out for Sancti Spiritus, Camaguey province, in 24 hours. Cuban American Drilling and Exploration Co. has contracted with Simpson to drill three 10,000-foot wells. The rig was being set up on location for the first well, which is located eight miles east of Sancti Spiritus on the Central Highway route to Jatibonico.



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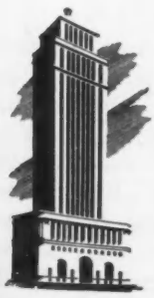

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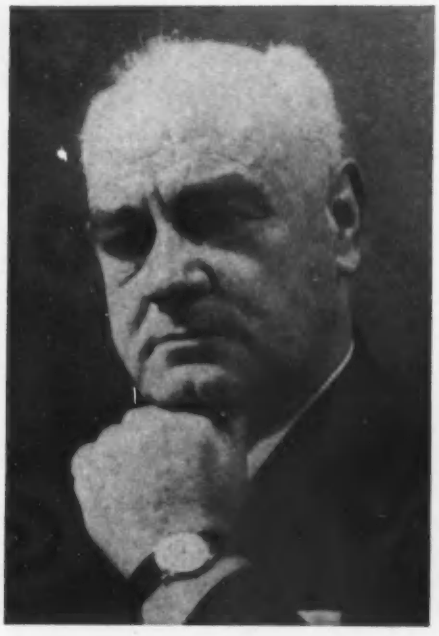
What's Happening

AMONG WORLD OIL MEN



Capt. W. M. Hutchison

Lord Godber

F. N. Judson

Five prominent men long associated with the British Empire oil industry were honored in the 1956 New Year's Honors List.

CAPTAIN W. M. HUTCHISON was made a Commander (of the Order) of the British Empire. Captain Hutchison has been marine superintendent of The British Petroleum Company since 1943. He joined the British Tanker Company in 1919. In 1935 he took up duties at the head office as assistant marine superintendent of BP. He is a Liveryman and also a Freeman of the City of London, a member of the Court of the Honorable Company of Master Mariners and a Fellow of both the Geographical Society and the RSA.

GROUP CAPTAIN D. R. S. BADER, DSO, DFC, also was awarded the CBE. Group Captain Bader is manager of Shell's Group Aircraft Operations department, and for many years has been active in behalf of the disabled. It is for his services on their behalf that he was accorded this honor.

SIR FREDERICK GODBER, chairman, Shell Transport and Trading Co. Ltd., a parent company of the Royal Dutch/Shell Group, was created a baron in the Honors List. Sir Frederick, now Lord Godber of Mayfield in the County of Sussex, joined Asiatic Petroleum Co. Ltd. (now Shell Petroleum Co., Ltd.) in 1904. In 1929 he became a managing director of the Group, a position which he held until 1946, when he became chairman of Shell Transport and Trading. Throughout World War II, he was chairman of the Overseas Supply committee of the Petroleum Board and was knighted in 1942 for his services to the Allied cause.

F. N. JUDSON, industrial general sales manager, Mobil Oil Company Ltd., was made a Member (of the Order) of the British Empire in recognition of his contribution to the oil industry during his 41 years' association with Mobil Oil. In his long career, he has served in many areas of the United Kingdom and for four years in China.

H. J. DIXON, assistant aviation insulation superintendent, Regent Oil Company, Stourport, was awarded the BEM for his long service in the oil industry. He has been with Regent Oil since its formation in 1940 and, prior to that, was with the Regent Group in 1938.

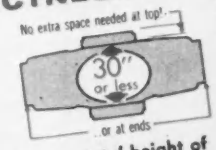
EDGAR H. CLAYTON has been appointed vice president and general manager of Colombia Cities Service Petroleum Corporation, with headquarters in Bogota. He will be in charge of developing El Carare area, comprising 2.2 million acres of oil land. Operations will be carried on by Colombia Cities Service under contract with Colombia's government-sponsored oil company, Empresa Colombiana de Petroleo.

Clayton will be assisted in Bogota by ZENAS STUCKY, formerly of Bartlesville, Okla., a geologist with experience in both foreign and domestic operations. For the past three years, Stucky has been manager of exploration for Canada Cities Service Petroleum Corporation. Stucky, with a geological staff, will begin exploration operations immediately.

•

FRANCIS J. HIMBURY has been appointed manager of public relations of Canadian Oil Companies, Ltd. He has been associated with Canadian Oil Companies, Ltd., since 1939 and prior to his new appointment was assistant to the president. In his new capacity he will direct public relations activities from the company's head office at Toronto.

GREATER COMPACTNESS!



Because of the side-opening doors, no extra space need be allowed above the gate—or at the ends—for servicing rams. Even in sizes as large as 13⅝" (12" Series 900) Shaffer Hydraulic Double Gates have a total height of only 30". No extra space above or at the ends is necessary!

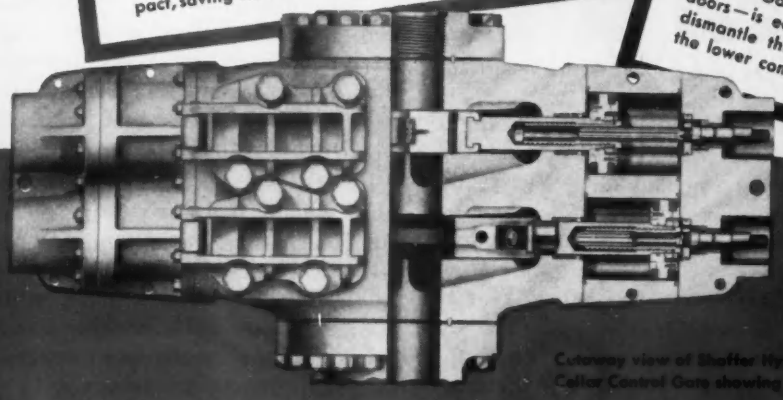
Width and length dimensions are also unusually compact, saving valuable cellar space in all three dimensions.

GREATER ACCESSIBILITY!

Shaffer's patented side-opening doors provide unmatched simplicity in servicing rams. Simply unbolt and open the doors—change rams—and bolt the doors shut again. Closing the doors automatically aligns the rams within the gate.

Double Gates, each compartment has its own set of doors—is equally easy to service. There's no need to dismantle the upper compartment to change rams in the lower compartment—or vice versa.

And in Shaffer Hydraulic

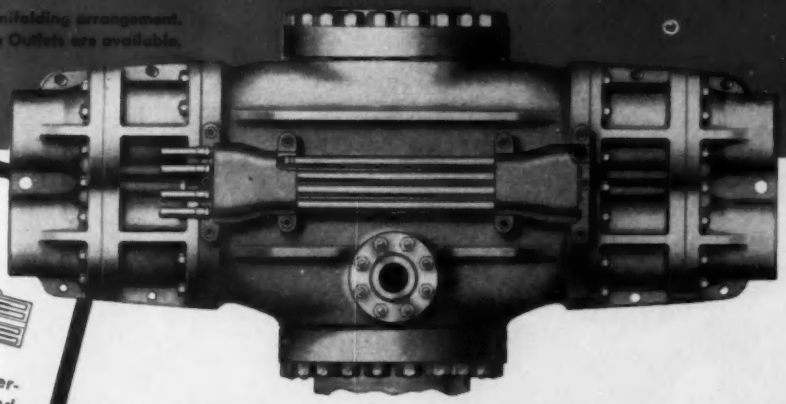


Cutaway view of Shaffer Hydraulic Double Cellar Control Gate showing simple design.

BUYING HYDRAULIC CELLAR CONTROL GATES?

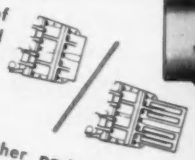
Check these Shaffer advantages against the field!

Rear View of above Gate showing manifolding arrangement. Both Single and Double Outlets are available.



GREATER CHOICE!

Shaffer provides a choice of Single or Double Gates...and a choice of Rising or Non-Rising Locking Shafts. Choose the type and Locking Shaft design that best meets your particular requirements. Rams and most other parts are interchangeable, size for size, for minimum inventory and maintenance costs!



GREATER EFFICIENCY!

Only Shaffer provides Self-Draining Compartment Bottoms with rams traveling on high guide ribs where no detrimental sand or mud can accumulate. Also, Direct Hydraulic Drive (no yokes or complicated secondary connections between rams and hydraulic pistons)... Completely Enclosed Design (no exposed moving parts to become damaged or corroded)...and many other advantages make Shaffer Hydraulic Gates the most dependable, most trouble-free available.

SHAFFER ... pioneers of cellar control gates—not only brings you equipment backed by more than three decades of experience and field-proven dependability, but also gives you *important advantages* found in no other pressure control equipment. Compare them, feature by feature, with other units.

GET ALL THE FACTS on Shaffer's many advantages from your nearest Shaffer representative. Or write direct!

Ask for Shaffer's complete catalog!

Consult the Shaffer Section of your Composite Catalog!

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Lord Strathalmond

Basil R. Jackson

Neville A. Gass

Maurice Bridgeman

The board of directors of The British Petroleum Company announced that LORD STRATHALMOND, chairman, planned to retire from his post March 31. On that date he completed 33 years of service as a director of the company, 28 years of which he was chairman or deputy chairman.

It was the board's intention, the announcement said, to appoint BASIL R. JACKSON, deputy chairman, to be chairman and NEVILLE A. GASS to be deputy chairman as of April 1. THE HON. MAURICE BRIDGEMAN was to be appointed director to fill the vacancy on the board resulting from Lord Strathalmond's retirement.

In 1921 Jackson joined Anglo-Iranian Oil Company (the name was changed in 1954 to The British Petroleum Company) and worked in the Production department in London until 1929. In 1930 he opened the company's office in New York, and remained there until 1935, when he returned to London to take charge of English oil field operations then being developed. After World War II began he went to New York and, on U. S. entry into the war, he was appointed by the Petroleum Administrator for War as one of two British representatives on the Foreign Operations Committee.

Jackson was appointed a director in 1948. He succeeded Sir Hubert Heath Eves as deputy chairman in 1950.

William Fraser, 1st Baron Strathalmond, was named after his father, the late William Fraser, founder and managing director of the Pumpherston Oil Company, the leading Scottish shale oil company. In 1909 he joined his father's company and visited Canada and the U. S. In 1913, at the age of 25, he became a director, succeeding his father as managing director on the latter's death in 1915.

In 1918 he visited the U. S. as chairman of the Inter-Allied Petroleum Conference Specifications Commission, which dealt with specifications and supplies of petroleum productions for the allies in World War I. He was created a Commander of the Order of the British Empire in 1918 for war services.

In 1919 he formed Scottish Oils Ltd., which combined the producing and marketing interests of all the Scottish shale oil companies under Anglo-Persian Oil Company, as BP was then named. He became a managing director for the latter company in 1923, deputy chairman in 1928 and succeeded the late Lord Cadman as chairman in 1941.

Achievements of his business career included his participation in the development of Iraq Petroleum Company group, formation in 1931 of Shell-Mex and BP Ltd., as joint marketing company for BP and Shell group in Great Britian and Ireland, negotiation in Tehran of the 1933 agreement between Iran and Anglo-Persian, formation in 1934 of Kuwait Oil Company (in which BP and Gulf Oil Corporation are equal partners).

In and after 1951, when Iran nationalized its oil industry, Lord Strathalmond was engaged in various efforts to settle the dispute as well as the reorganization of his company following suspension of operations in Iran. In 1954 he played a leading role in forming the consortium of international oil companies which in November, 1954, settled the dispute and began operation of the Iranian oil industry.

Gass joined Anglo-Persian in 1919 and served in Iran until 1934, when he was transferred to London. He has been a managing director of the company since 1939.

The Hon. Maurice R. Bridgeman joined the then Anglo-Persian company in 1926. After two years in Iran, he worked in the company's London office until World War II, except between 1934 and 1937 when he was the company's New York representative. During the war he was in various government positions connected with petroleum. He rejoined BP in 1946.

Rimrock Crew Leaves for Israel

President William C. Kneale of Rimrock Tidelands, Inc., bids goodbye to the first Rimrock crew dispatched to Israel, where they will supervise drilling operations for Matsada United Drilling Company, Ltd. Crew members who departed from New York, left to right, are J. E. Shafer, toolpusher; Ernest L. Roberts, James M. Faust and W. K. White, drillers. Under a recent agreement, Rimrock Tidelands will furnish up to six drilling crews and a drilling superintendent to supervise drilling operations and to train Israeli personnel for Matsada, operating subsidiary of Lapidoth-Israel Petroleum Company, Ltd., which brought in the Israeli discovery well last fall. Shafer, Roberts and White have had previous drilling experience in Greece.

R. W. DIAMOND, JR., statistician with Canadian Petroleum Association, Calgary, has joined the executive staff of Triad Oil Co. Ltd. WILLIAM D. STUART, formerly in the land department of Imperial Oil Limited, has been appointed to the position vacated by Diamond.

•

D. M. MORRISON, M.B.E., has been elected president of the Trans Mountain Oil Pipe Line Company, with headquarters at Vancouver.

A native Nova Scotian, Morrison has been associated with Shell of Canada and Shell Oil Company in the U. S. since leaving Cambridge University. From 1942 to 1944 he served with the Canadian government in the Explosives and Chemicals division of the Department of Munitions and Supply. He was awarded the M.B.E. for his outstanding wartime work. On leaving the department, he returned to Shell of Canada as manager of the Montreal refinery.

From 1951 to 1953, Morrison served as the government's director of the Petroleum division of the Ministry of Defense Production. In 1953 he returned to Shell of Canada, where he was appointed vice president in charge of manufacturing, the position which he held immediately before his election as president of Trans Mountain.

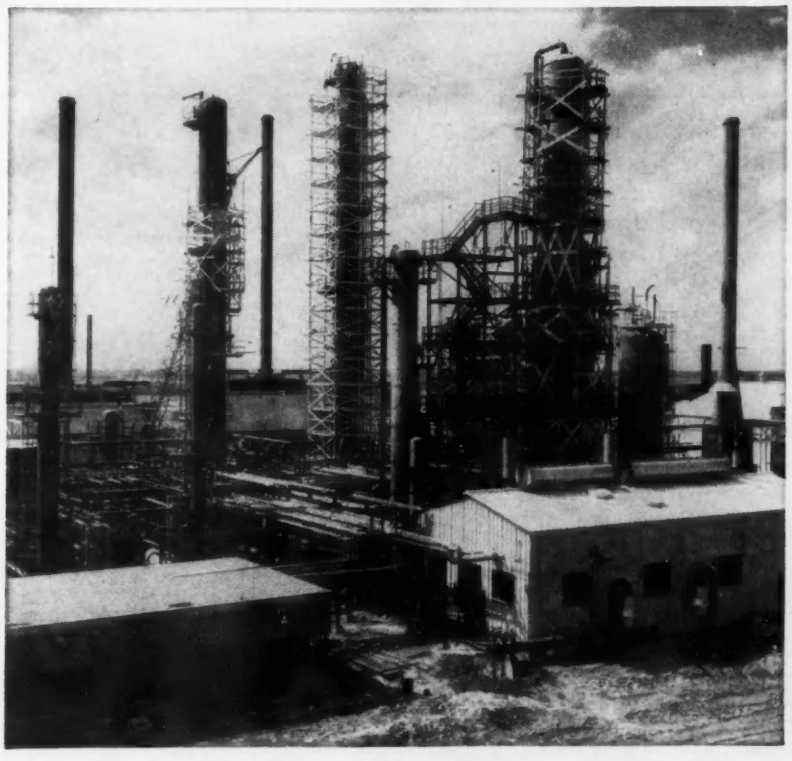
•

DON ANDERSON of Calgary, Canada, has been named local manager of operations for Canada-Cities Service Petroleum Corporation.

Anderson, who has been superintendent of oil operations for the Canadian company four years, will supervise all operations of the company—including production and exploration. In his new job, he assumes exploration responsibilities of Z. E. Stucky, who is being transferred to another Cities Service operation.

Anderson was first employed by Cities Service in 1930 as an engineer in Cities Service Oil Company's Bartlesville, Okla., headquarters. Two years later, he was transferred to Cities Service Gas Company and was engaged in gas transmission, production and dispatching activities in the Mid-Continent area of the U. S. His transfer to Calgary as superintendent of oil production came early in 1952.

New forests are growing in Western Canada



Forests of steel and concrete now tower over the level plains of Western Canada as refineries have sprung up to convert crude oil to the needs of industry, and capitalize on the vast wealth of Canada's petroleum resources.

If your own interests include Canadian oil, in any of its aspects from exploration and drilling equipment to refineries and pipelines, it will pay you to make use of The Canadian Bank of Commerce. More than 150 of our branches are located in the western Canadian oil fields. The men in our Petroleum and Natural Gas Department in Calgary are well versed in the problems encountered by United States and Canadian companies active in that area.

For further information, write to our Business Development Division, Head Office, Toronto 1, Canada—or direct to our Petroleum and Natural Gas Department, 309-8th Avenue West, Calgary, Alberta.

(We do not advise on the merits of specific oil securities)

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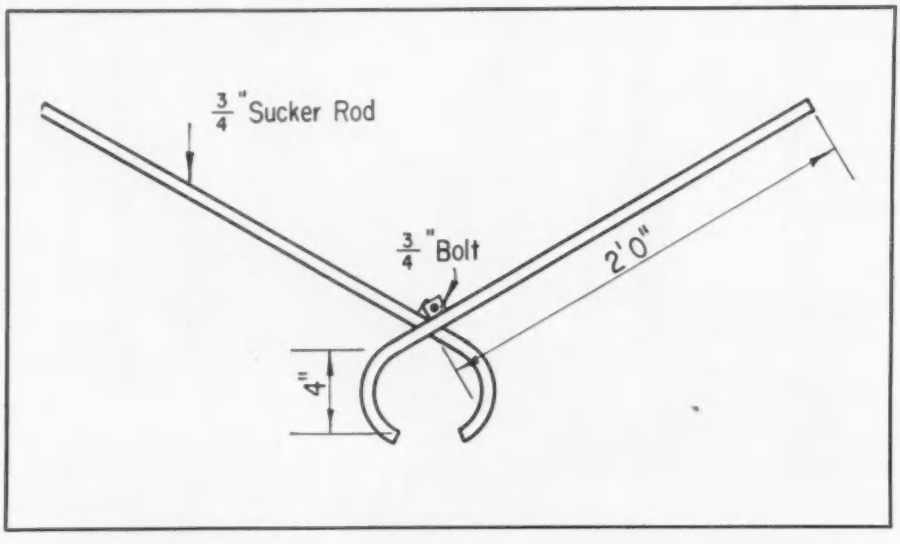


Pipe Carrier Can Be Made from Scrap

When making and breaking location there usually is quite a bit of line that must be laid for water, mud, sometimes for fuel, and a flow line for oil. These usually are 2-, 3- and 4-inch. Moving and carrying this pipe by hand is tiresome and sometimes results in an accident if the pipe should slip.

One contractor had a few inexpensive pipe carriers made from scrap that have been a big help to his pipe-laying chores. Two pieces of sucker rod about three feet long are used. One end of each piece is heated and curved by hammering around a 4-inch piece of pipe to form a semi-circle 4 inches in diameter. A ¾-inch nut is welded to each rod just above the bend. The two rods are joined together by inserting a piece of rod, just smaller than the hole in the nut, and peening the ends so that it cannot be removed. This results in a crude but effective pair of pipe carriers. Any size pipe up to 4 inches can be carried by four men without the danger of anyone being hurt if the pipe slips.

How-To-Do-It Ideas Earn Money, too!

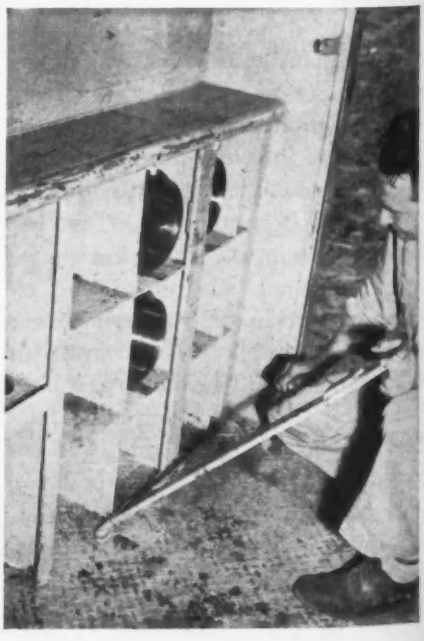
$10—WORLD OIL editors want how-to-do-it ideas, so your favorite short cut or invention could put money in your pocket! Write down the substance of that latest idea and send it in with a picture or drawing of the installation . . . if accepted, $10 will be yours. Send those money-making ideas today to Hints Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

Liner Storage Rack Facilitates Inspection

How to store pump liners safely where there is no chance of their becoming damaged through contact with other metal objects, or with each other, yet are readily available when needed has been solved by a Canadian operator.

In one corner of their skid-mounted, enclosed tool and parts house, a small section near the floor is partitioned off to form nine pigeon holes. Each hole is just large enough to accommodate a liner without having excess space around it. Made of ¼-inch steel plate, this sturdy cabinet is open at all times for rapid inspection of the liners stored there.

To prevent liners from slipping out



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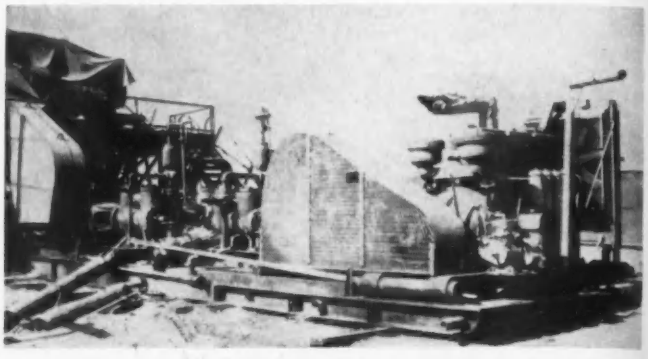
when moving between wells, a pair of ½-inch steel plate retaining bars are hinged at the floor and overlap the adjacent partitions. As can be seen in the photograph, the openings, even with the retaining bars in place, allow ample room for measuring inside diameters and checking condition of the surfaces. Much time and effort is saved when new liners are needed by being able to determine size and condition without having to handle all of the spare liners.

Mount Both Mud Pumps on One Skid



One south Texas contractor has both mud pumps mounted end to end on a single skid base so they can be moved in one load. This makes approximately a 90,000-pound load, not unusual for today's oil field trucks. When the unit is spotted on location it is necessary only to align the main pump with the drive from the engine compound and connect up the mud lines and fuel lines.

The skid base is approximately 25 feet long and 8 feet wide. The one end contains the mud pump in the usual position which is driven from the engine compound on the rig floor. The other end has the stand-by pump and engine with the pump turned towards the rig floor. This puts all suction and discharge piping together and simplifies connection work. Two pumps on a single skid is a time-saver on moves and a compact arrangement on location.

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15,000,000
feet of TK-2 coated tubing are in use!

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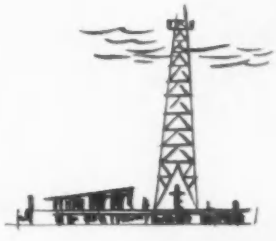

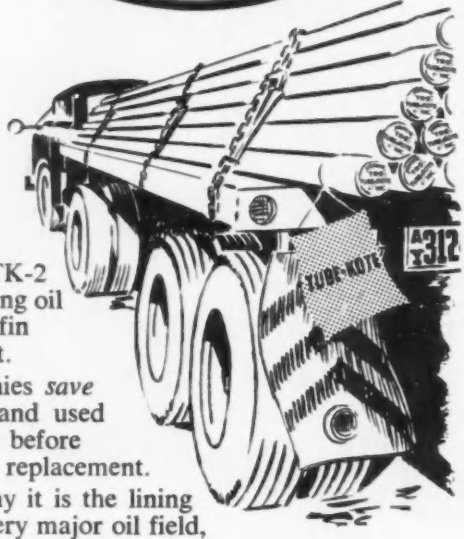

15,000,000 feet in use . . . twice as much as in 1954 . . . proof of TK-2 dependability in preventing oil field corrosion and paraffin troubles before they start.

Result: more oil companies *save* money by coating new and used tubing with TK-2 plastic before corrosion damage forces replacement.

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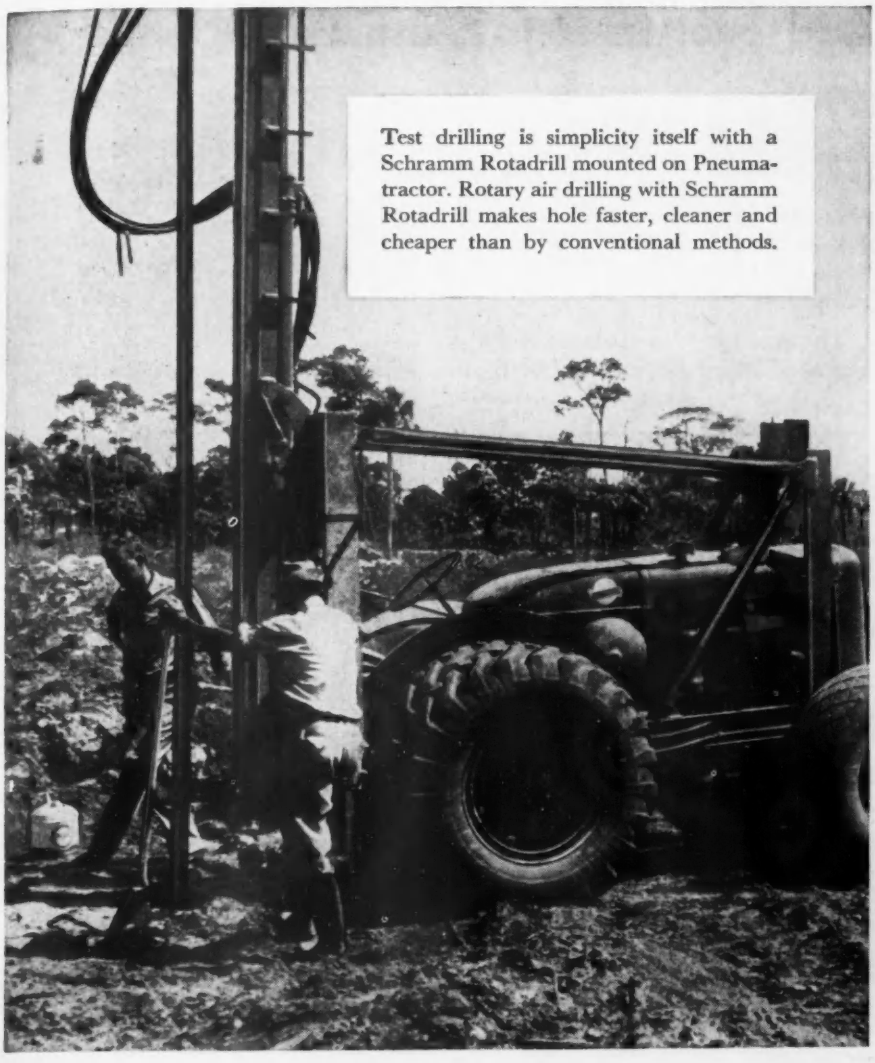
Spools on Utility Shed Provide Line Storage

Spools fabricated from scrap plate metal and short lengths of casing can be mounted on the side of the utility shed for storing or transporting excess lines or hoses. As each location requires slightly different spotting of the utility shed in relation to fuel supply, rig floor, mud house, etc., it is necessary to carry sufficient electrical wiring and fuel hoses to connect up any reasonable arrangement.

When there is a surplus amount of wire or hoses they should be coiled or racked and not just left on the ground. Also, electrical lines and fuel lines should be properly coiled for transporting.

One contractor mounts three spools



Test drilling is simplicity itself with a Schramm Rotadrill mounted on Pneumatractor. Rotary air drilling with Schramm Rotadrill makes hole faster, cleaner and cheaper than by conventional methods.

SELF-PROPELLED. The new Schramm Rotadrill is mounted on the Schramm Heavy Pneumatractor. Special weight boxes, dual wheels and the use of calcium chloride in rear tires add necessary weight to provide 10,000 lbs. down pressure. Schramm Rotadrill is also available truck mounted.

CONVENIENT, SIMPLE CONTROLS. Drilling controls are mounted in one bank, with pressure regulator and hydraulic gauge for controlling down-feed. Separate valves control each outrigger, forward and reverse rotations motor, slow downfeed, rapid downfeed and breakout cylinder.

ADDING PIPE. Fast vertical action of rotative head serves as pipe hoist for adding pipe or pulling drill string. Output spindle is flanged to take various drill pipe adaptors.

EXPLORATION CREWS SET NEW RECORDS:

Drill test holes fastest ever with self-propelled drilling rig

With the development of the new Schramm Rotadrill, exploration crews gain all the advantages of rotary test drilling with compressed air. This comparatively new technique, developed in the oil fields, has been setting drilling records in almost every case. It is believed that rotary rock drilling, with its advantages of fast, clean holes, fast set-up, and longer bit life, will completely replace the use of wagon drills.

Schramm's new Rotadrill on Pneumatractor is a complete, self-contained unit, self-propelled and self-powered. The unit can drill a 4¼" hole, or smaller, to a depth of 500 feet with 10,000 pounds down pressure. Normal compressed air drilling pressures of 20-30 psi can be instantly increased for dewatering or breaking out blockages. Drilling controls are mounted in one complete bank, conveniently located for one-man operation. Standard Rotative Head has 75 RPM output and can be throttled down to complete stall while maintaining constant torque. Heavy welded structural steel mast, lowered for traveling between jobs, can be operated at various angles for sloping holes.

If you use wagon drills, you will find it worth while to investigate the Schramm Rotadrill on Pneumatractor. Send today for Bulletin PR-55. There is no obligation.

Your local Schramm Dealer is listed in the Yellow Pages of your Telephone Directory.

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(For more data on advertised products, use Readers' Service blue cards, last page this issue.)

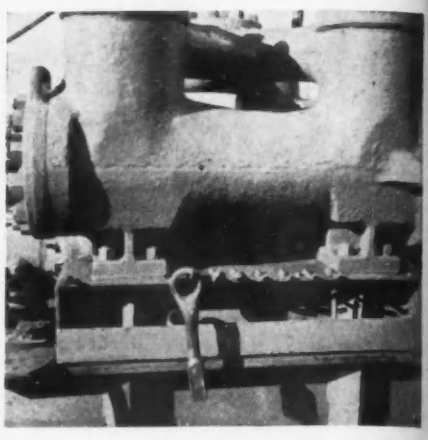
on the utility shed. The largest one is for the fuel line to the engine that runs the light plant. A spool also is provided for the electrical line that goes to the mud house and pumps, and another for the electrical cable that goes to the derrick and floor string.

These spools, mounted so that they are not in the way during moves, provide a handy place to coil these lines when moving.

Add Tool Rack to Slush Pump Base

When pump trouble is indicated it is necessary usually to tear into the pump and make repairs as quickly as possible. To make sure that the hammer-up wrenches are handy and spare nuts available, one contractor made a small tool bin and wrench rack on the pump base.

The tool bin was made by welding scraps of metal about the "I" beam



base of the pump to form a box or bin. A 4-inch strip of metal that enclosed only about half of the front formed the bin effect.

Six short pieces of sucker rod were welded above this and then bent slightly to form a convenient peg for the wrenches.

Everything from nuts to packing gland parts was kept in the bin and was available when needed.

Built-In Reservoir Keeps Lubricant Clean

A convenient, shop-made reservoir has been fabricated by one contractor to keep plunger rod lubricant as clean as possible. A short section of casing or pipe is closed by welding circular pieces of plate metal across the ends forming a small tank. Three openings are cut out so that two 2-inch collars and one 1-inch collar can be welded onto the tank. The drain line from the pump rod housing is connected to the side of the tank and the 1-inch line to the small rotary pump is connected near the bottom on one end. A plug is inserted in the 2-inch collar

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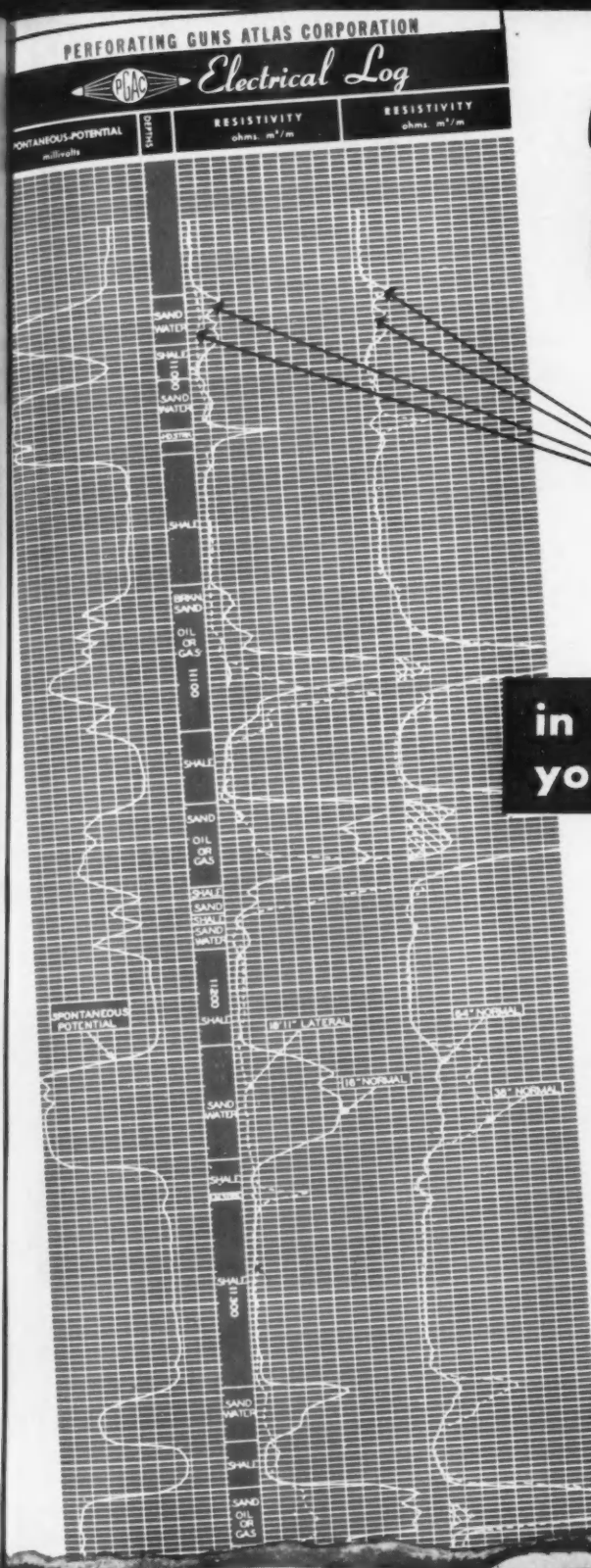

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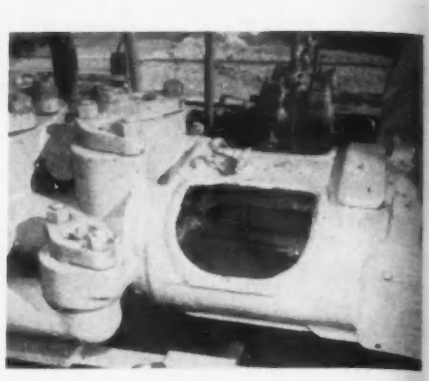
GERMANY — Atlas Deutsch- Amerikanische Olfelddienst G. m. b. H.; Kiel VENEZUELA — Servicios Tecnicos Atlas, C.A., Caracas

on top and is removed for filling the tank.

The tank is installed in the flooring of the pump skid and is tack welded in place. This prevents anyone working around the pump from accidentally kicking the tank over and spilling it. Also, due to the lack of sharp corners, this type of rounded tank cuts down on the safety hazard.

Oil Bath Protects Mud Pump Piston Rods

To keep piston rods lubricated on little-used auxiliary pumps, put a drain line and valve on the bottom of the cross head housing and fill the compartment with thin lubricating oil. When the pump is shut down, the rods are immersed in oil where they will not rust. When the pump is running, the rods run in a flood of oil and are kept clean and lubricated. If any water or mud should leak through the packing gland on the pump, it settles to the bottom and is drained off at the foot valve.



In the photograph, the oil was drained down to show the piston rod partly submerged, but in operation, the compartment is filled near the brim and the rod is entirely covered with lubricant.

Covers for the packing gland access opening can be provided to protect the oil bath in case of very wet or very sandy locations.

We are mighty proud that the George E. Failing Company selected Foster Midget Master Catheads as standard equipment on their new Stratmaster Slim Hole rig. This new 6,500′ drilling rig teamed with Foster Midget Masters will deliver maximum efficiency with minimum overhead expense.

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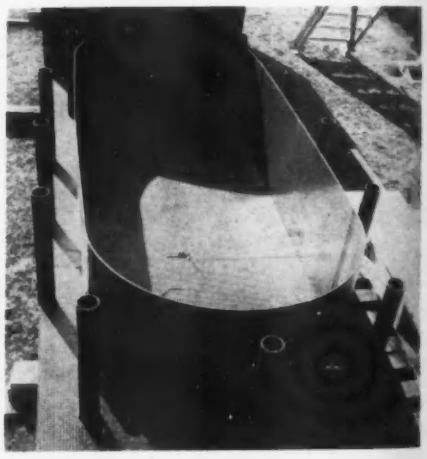
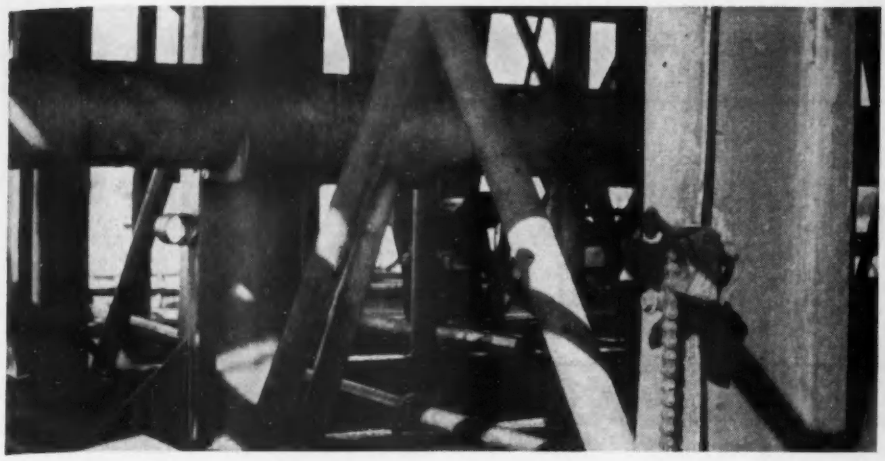


Rig Rotary Hose Carrier Around Oblong Tool Bin

Proper care and handling of the rotary hose will insure longer service life. A suitable storage and carrier should be provided for the spare rotary hose and also for the regular hose where long moves are made.

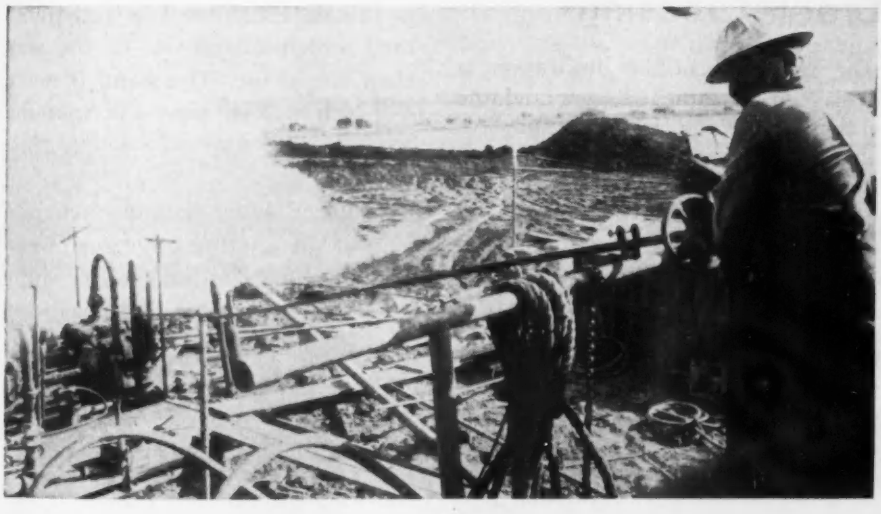
One contractor had a hose carrier made around an oblong tool bin. The bin was skid-mounted with the flooring extending out beyond the bin. Two-inch pipes, the same height as the bin, were positioned around the bin to form a rack for the hose.

A spare hose could be left coiled around the bin until needed. With or without the hose in place the bin is accessible and there is always a place for the rig hose when tearing down and moving the rig.



Make a Permanent Pipe Working Place

As there is always a considerable amount of pipe fitting and connection work to be done when rigging up, one contractor welded a pipe vise to a leg in the substructure at a convenient height for the crew. On an inner leg at the same height a 4-inch collar was welded. Pipe sizes up to 3-inches could be handled by stabbing one end through the collar for support and fastening the end to be worked on in the pipe vise. The pipe is held securely and at a convenient height for threading or breaking-out old connections. Such an arrangement will replace the common practice of two or three crew members with 24's and 36's trying to hold pipe while it is being threaded or other connection work is being performed.



Valve Extension to Derrick Saves Steps

When steam pumps are spotted several steps from the rig floor, it is time-consuming for the roughneck to walk out to the pump every time a connection is made. One contractor has made an extension for the steam pump throttle valve stem which reaches to the edge of the derrick floor. Here it is in easy reach of the crew members when necessary to shut the pump down momentarily.

The extension was made by placing a fork over the existing mud pump valve wheel and connecting it to a length of one-inch pipe. Supporting posts made of 2-inch pipe were driven into the ground with fork arrangement on top made from links of rotary chain. A universal joint from a model T was placed midway in the one-inch pipe to allow for a bend. A gate wheel with a crank on the rim was then attached to the other end of the valve extension to make it easy to open or shut the valve.

Another DARCOVA first!

100% NYLON COMPOSITION

DARCOVA VALVE CUPS, SEATING CUPS, AND SEATING RINGS

—long noted for outstanding performance in well pumping—are now available in 100% nylon composition for *extra* strength, *extra* life!

They are offered in the full range of precision sizes and Darcova textures that assure peak efficiency under varying conditions of depth, pressure, temperature, corrosion and abrasion.

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The *original* . . . and *always* the best!

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THE ORIGINAL COMPOSITION CUP

PRODUCTION HINTS

These How-To-Do-It Ideas Can Save You Money

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

Pipe Protects Line at Creek Crossing

When necessary to cross a creek bed with a plastic flow line, a few joints of scrap 6-inch pipe will protect the plastic from damage in that area after it is layed and will help make the crossing easier.

By cutting and welding the steel pipe as shown in the illustration, a cable can be attached to it and the entire length slid into position. An elbow on each end of the plastic pipe keeps it relatively secure inside the 6-inch. Once the unit is in place, connections can be made at each end and the plastic line continued.

Make Coupon Port from Four-Way Tee

An excellent coupon port can be made from a 4-inch 4-way tee. This port will handle up to eight coupons.

The tee is installed in the flow line with a flat plug used in the bottom outlet. The top opening is fitted with a similar flat plug to which a short rod has been welded. The rod, cut to an appropriate length, is used to hold the coupons in the center of the flow line. So that it may handle various length coupons, the holding rod may be slotted. The illustration shows the various parts of the coupon port and how it is incorporated into the well system.

Hinged Floor Extension Speeds Well Servicing

When flood waters make it necessary to mount the pumping unit on a platform, the polish rod often is several feet away, making maintenance operations around the polish rod and horsehead difficult. Extending the platform floor puts it in the way of blocks and elevators when a pulling unit is required for service operations.

To solve this situation, a company in Illinois constructed a collapsible stand which folded out of the way when not in use. The stand is made of 2-inch welded pipe and uses the same flooring material as the platform.

A hinged brace extends from the front of the stand to a horizontal stiffener on the platform as shown in the illustration. To prevent the brace from slipping off the stiffener, a short piece of pipe is split in half lengthwise and welded to the bottom of the brace. This fits snuggly around the

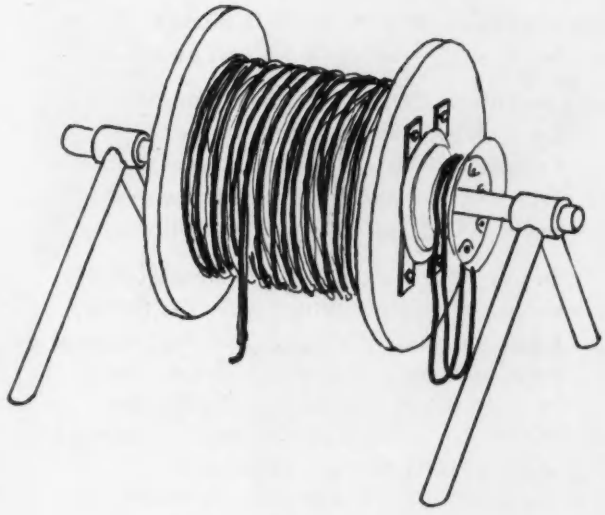
How-To-Do-It Ideas Earn Money, too!

$10—World Oil editors want how-to-do-it ideas, so your favorite short cut or invention could put money in your pocket! Write down the substance of that latest idea and send it in with a picture or drawing of the installation . . . if accepted, $10 will be yours. Send those money-making ideas today to Hints Editor, World Oil, P. O. Box 2608, Houston 1, Texas.

Tire Rim Speeds Cable Spooling

An old automobile tire rim welded to a pair of metal strips aids a service operator in spooling old line off of the truck reel when cable repair or exchange is necessary.

The metal strips vary in size with the size of spool being operated. They are bolted securely to the spool and the entire unit placed on a pipe stand as illustrated. V-belts are run from the tire rim on the spool to a similar rim attached to a pick-up truck rear wheel.



With the legs of the stand firmly embedded in the ground, the pickup can be moved until the V-belts are tight and then jacked up. By running the cable off of the reel and regulating the speed of the spool there is comparatively little strain on the V-belts.

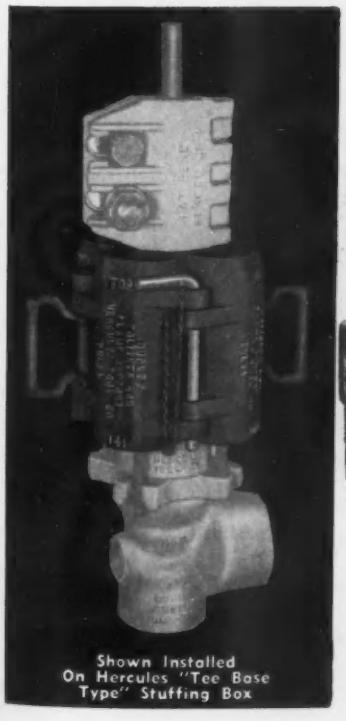
Actually any source of rotary power available could be used to turn the spool. It is even possible to use the truck from which the cable is being pulled as a source.

stiffener when the stand is raised reducing the possibility of accidents.

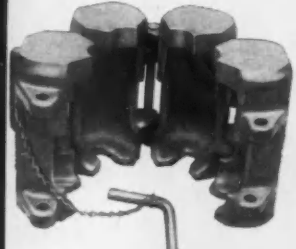
Hinges for this stand are made of old sucker rod slipped through holes in ears welded to the stand and the platform. This unit provides simple, inexpensive access to the polish rod and horsehead for maintenance and still provides room required for servicing the well.

Prevent Damage to Packing and other Component Parts with a

HERCULES POLISHED ROD CLAMP-OFF SUPPORT



Developed to prevent damage to the packing and other component parts of Hercules Stuffing Boxes while "clamping-off." Transmits weight of rods to tubing by resting upon top of the Stuffing Box body. Fits all types Hercules Duplex Stuffing Boxes. Made up of four sections hinged together, making it easy to install around Stuffing Box and is locked by means of a latch pin. Handles are provided to facilitate handling. Constructed of high grade malleable iron. Will accommodate all size polished rods and liners up to and including 1¾". Will safely support the longest string of rods.



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Export Representative: Oil Field Equipment Co., Inc., 30 Church Street, New York 7, N. Y.

Do You have a "Frac" Well that's tough to Pump?

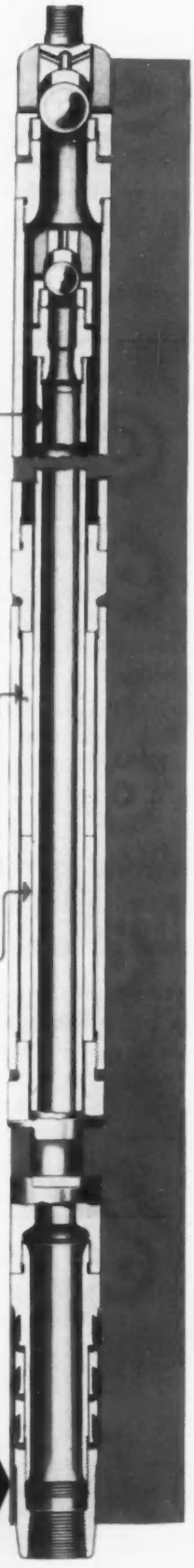
THEN **you should try a Pacific "OIL STATES" rod insert, bottom hole oil well pump...**

WHY? **because the "OIL STATES" is pumping some of the toughest, sandfrac wells in the Mid-Continent fields—from the extreme depths in West Texas and the gulf coast to the shallower zones in Oklahoma, Kansas and Illinois...**

In well after well, oil operators report highly successful pumping with Pacific "Oil States," particularly after trying cup and ring pumps or metal-to-metal pumps with wide tolerances between plungers and tubes. The Pacific "Oil States" offers a new approach to pumping sandy or dirty oil wells. Specifically manufactured to a very close tolerance between plunger and liners, so as to eliminate sand passing between the sealing surfaces which normally cut and score plunger and liners. The Pacific "Oil States" is not merely a "clean-out" pump. It is engineered to pump sand with its "surging action" and further, to pump with a high efficiency made possible only by the close tolerance.

Check these features:

- Furnished with a tolerance between plunger and liners in fits as close as Minus ½ thousandth...
- Furnished in standard steel with stress-proof, heat treated fittings for normal sandy pumping...
- Furnished with stainless steel barrel and parts with "PACILITE" Hard Chrome Plunger for corrosive conditions...
- Furnished in "Stroke-Thru" design to eliminate sticking of plunger and liners in wells that deposit gyp or barium.
- Furnished in pump lengths from 4 feet to 20 feet, with a wide choice of arrangements of valves and fittings...
- Furnished in the following sizes and bores:
  1" and 1¼" for 2" tubing
  1½" and 1¾" for 2½" tubing
  2¼" for 3" tubing
- Plunger and Liners can be "Reground" several times to give the most economical repair costs...



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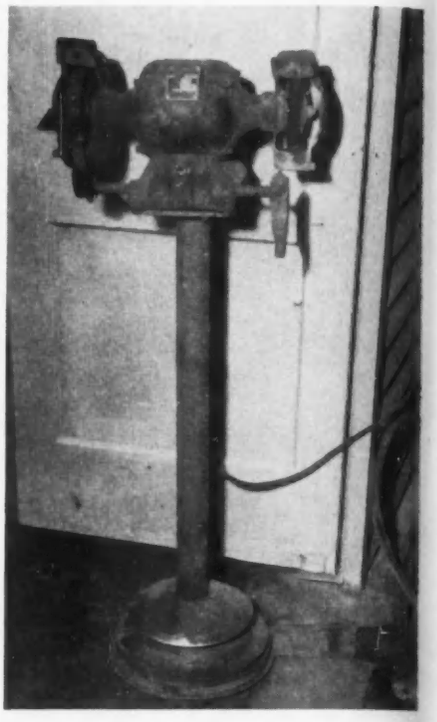
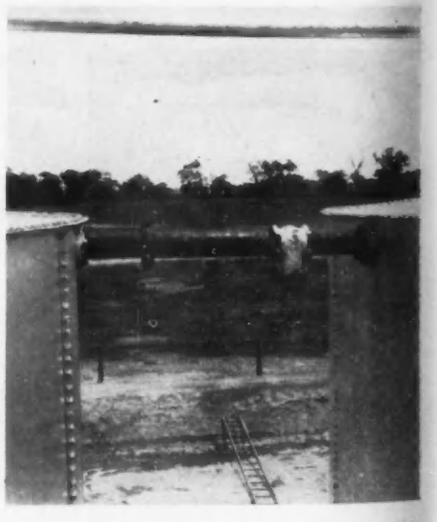


Make Good Grinder Stand From Old Brake Drum

Brake drums make excellent stands for grinders. Not only are they durable and inexpensive, but they allow the stand to be rolled any place in the shop where the grinder is needed. Size of the brake drum can be varied with size of the grinder to prevent the unit from becoming top heavy.

This stand includes a hub cap which is placed over the brake drum to improve the appearance.



Tank Topping Unnecessary With Simple Connection

To eliminate having a pumper stand by to top a tank, one company installed a connection between two adjacent tanks. The arrangement at the top of the tank is illustrated. It

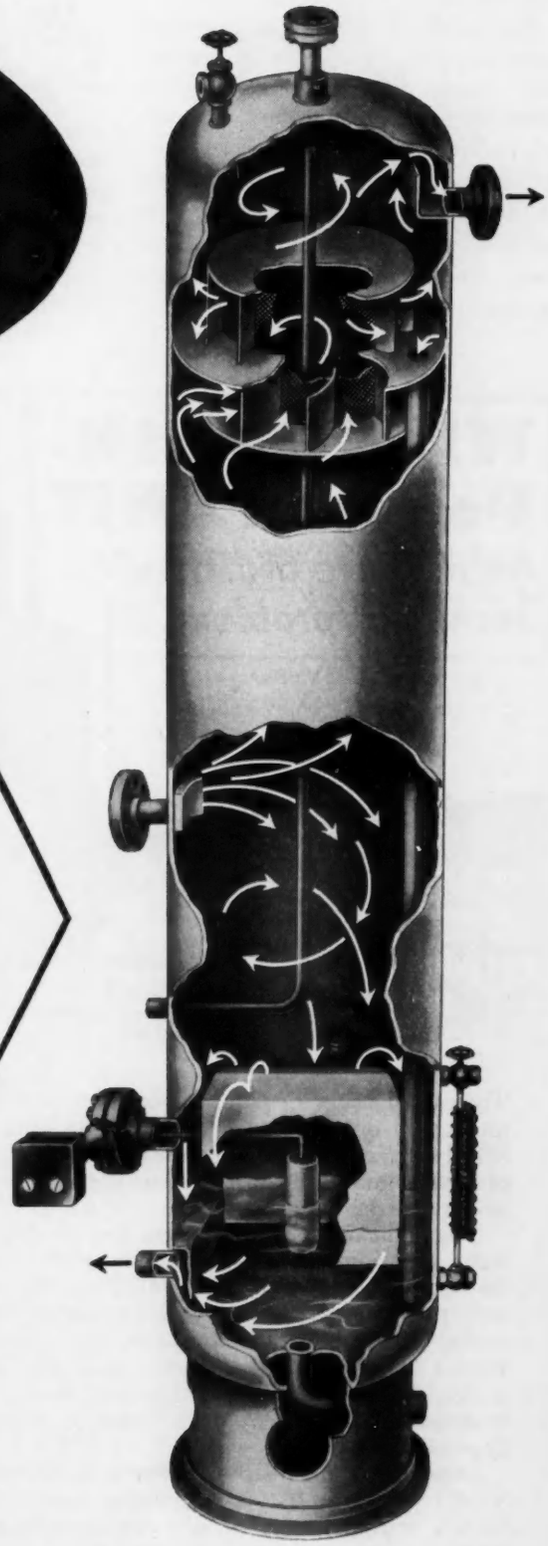
DRIER GAS.....

HIGHER OIL YIELD

Impingement, centrifugal force, gravity, surface tension, adhesion—all these forces are combined more efficiently in the Tyson Smith Co. TWO-STAGE MIST EXTRACTOR. That's the reason more and more of them are being installed throughout the oil fields of the Southwest.

- Two-Stage Mist Extractors
- More efficient separation of dry gas and oil
- Service by experienced personnel
- Proven control and safety devices
- Full range of capacities and working pressures
- Variety of capacities in each working range
- Two or more units give dependable stage-separation on multiple installations
- Tangential inlet

Specify TYSCO Vertical Separators on your next installation for quicker profits—and for greater profits in the long run.



Standard TYSCO Vertical Separator illustrated.

TYSCO

TYSON SMITH COMPANY

UNderwood 9-1425 P. O. Box 7398 Houston 8, Texas

consists of flanges, a gate valve and a coupling. A long fork is used to operate the valve from the ground.

When the fluid level in one tank nears the top, the valve is opened. Any excess fluid entering the tank flows into the second tank through the connection. When the pumper returns he can cut in the new tank and the full one is ready to be gaged. This method allows the pumper a little more freedom and is less time-consuming.

Inverted Box Protects Pumping Motor from Rain

This idea came from a lease in the Pierce Junction field of Harris County, Texas, where average amount of rainfall is quite high. When the life of a pumping unit motor was shortened considerably by blowing rain, the pumper decided to enclose the motor as shown in the photograph.

This inverted box arrangement is made of ⅛-inch sheet metal. It is constructed with close tolerance at the

shaft and a simple bolted tie-down method. This device has accomplished its task for motor life now is twice that of the longest period experienced before the boxes were installed.

WISCONSIN-Powered UNIT
helps solve a difficult technical problem...

Today salt water disposal is becoming more and more of a problem among oil operators, due to stringent state regulations and a constantly growing interest in water conservation programs. Pollution of surface and shallow fresh water strata can lead to litigation, higher losses and damages.

The solution of this problem lies in drilling salt water disposal wells and pumping the brine, produced with the oil, back into the formation. A high pressure (1000 lbs.) Wisconsin-Powered pumping unit provides a practical and economical means for handling salt water. The application illustrated here shows a pumping unit connected to a salt water disposal well with 2" fittings and pressure gauge. Pumps are made of aluminum bronze, stainless steel, ceramic material, lead bronze, etc., in order to stand up under this varying type of service.

Dependable, all weather power is delivered by a Model VF4D and VG4D Wisconsin V-type, 4-cylinder, heavy-duty AIR-COOLED ENGINE, equipped with Stellite exhaust valves and valve seat inserts, positive type valve rotators, tapered roller main bearings and other features that assure trouble-free service and lowest cost maintenance.

You can't do better than to specify "WISCONSIN POWER" for your equipment.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

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OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

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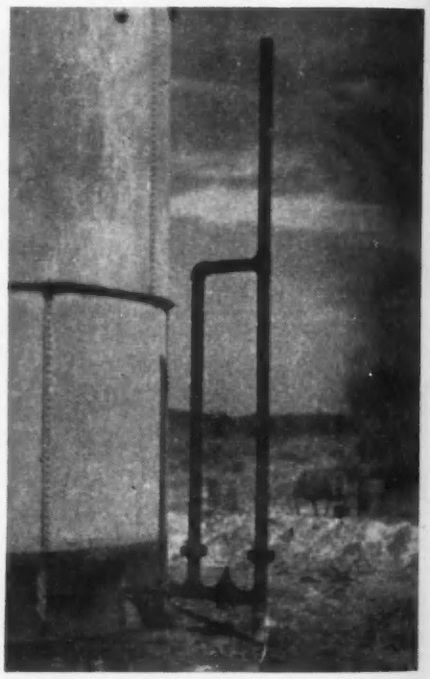


Simple Hookup Bleeds Salt Water from Tank

When a simple system for bleeding salt water from a gunbarrel tank is required, install a second valve in the salt water outlet line. Put a syphon connection around it, using two unions in the assembly. The unions allow the line to be removed easily for adjustment until proper water level in the tank is obtained. Once this level is obtained, the arrangement will bleed off to the correct level automatically.

Should it be necessary to drain the tank, open both valves and drain the tank directly through the by-pass.

Pumping Progress Report

FOR PETROLEUM ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

PUMPING LIQUID BUTANE AND PROPANE is a typical operational headache successfully handled by the Aldrich Pump Company Engineers. It was a particularly tough pumping problem for one large pipe line company; they had to move butane 186 miles — from a Texas oil field to a Gulf Coast refinery.

PUMPING LIGHT-GRAVITY FLUID AT HIGH PRESSURES required the positive displacing action of conventional reciprocating pumps plus the flexibility of capacity provided by centrifugals. And Aldrich Engineers knew the answer — the Aldrich-Groff Controllable Capacity "POWR-SAVR" Pump.

STEPLESS STRAIGHT LINE CONTROL OF CAPACITY, from zero to rated maximum output, was possible with the "POWR-SAVR". Pump delivery was automatically controlled to suit varying requirements and power consumption became nearly proportional to the rate of output, affording desirable power savings.

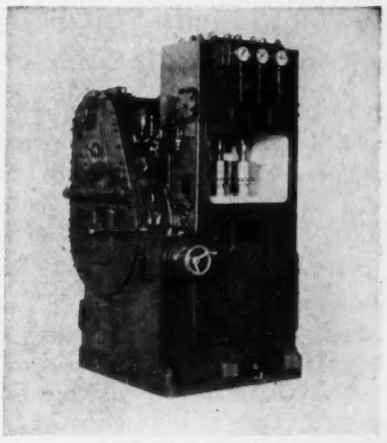
SURGE TANKS WERE ELIMINATED, due to the "POWR-SAVR's" ability to meet immediate changing line conditions. This eliminated associated evaporation losses, co-mingling of different batches, and much of the danger of handling highly flammable material. Gone, too, was the need for bypassing to handle excess quantities of pump output.

UPRIGHT DESIGN of the "POWR-SAVR" places discharge valves directly over the plungers and inlet valves at one side. Efficient valve action permits the pump to operate at the high rate of 240 rpm. Another design feature was the use of porcelain plungers, reducing packing and leakage troubles.

THE ALDRICH PUMP COMPANY has been solving the difficult pumping problems of American industry since 1902. We've never turned down a challenge — many of yesterday's tough pumping problems are today routine.

DATA SHEET 65A, describing the Aldrich-Groff Controllable Capacity "POWR-SAVR" Pump will be sent to you on request. Or our representative will be glad to call. Address your request to: The Aldrich Pump Company, 4 Pine Street, Allentown, Pa.

(Advertisement)



Aldrich-Groff Controllable Capacity "POWR-SAVR" Pump suitable for pumping butane and other light-gravity fluids.

...for your tough pumping problems specify ALDRICH

This machine is ideal for pumping light-gravity fluids at medium and high pressures. It combines features of superior efficiency and positive displacing action of reciprocating pumps with the flexibility of capacity of centrifugal pumps. A unique, reliable mechanism controls the plunger-stroke from zero to rated output without change of speed of power source, providing desired savings in power plus top efficiency.

Typical Applications for the Aldrich-Groff "POWR-SAVR" Pump:

Pipe Line Service **Process Charging**
Boiler Feeding **Oil-burner Supply**

Write for Data Sheet 65A, describing the features of the "POWR-SAVR" Pump. Or, if you prefer, our representative will be glad to call.

THE ALDRICH PUMP COMPANY

Originators of the Direct Flow Pump
4 PINE STREET
ALLENTOWN, PA.
Representatives in principal cities

Use Home-Made Stands To Replace Jack in Shop

A maintenance shop overhauling several vehicles at once found that inexpensive stands could be used safely to replace expensive jacks. Wooden blocks are hazardous and cumbersome compared to the stands illustrated above.

Made from rear axle housings of older type automobiles these stands have become standard equipment in this shop. Tops of the stands are cut with a welding torch to leave a groove as shown. This allows a more secure fit when they are placed under the axle of the vehicles being overhauled.

In case an extension is required, one may be made easily from a piece of pipe whose outside diameter is slightly less than the inside diameter of the cut housing. A steel ring is welded to the outside of the pipe and it, in turn, rests on the housing. By placing the steel ring closer to one end of the pipe than to the other, varying height can be obtained depending upon which end is placed in the housing.

An alternate style stand is constructed from 2-inch pipe and collars as shown at the left. By welding a collar to a steel plate and screwing in the 2-inch nipples, an excellent stand results.

From the makers of world-famous jacks comes the

NEW No. 5 JENSEN JACK with double and single gear reductions.

The NEW No. 5 JENSEN JACK is engineered to lift MORE oil for LESS money from any 1,000 to 1,500-ft. well. It has all the construction features that have made JENSEN JACKS famous throughout the world—heavy welded post and beam, precision shaved gears, oil bath lubrication, double tapered roller type bearings, single and double gear reductions—plus other JENSEN features.

Before you buy any jack, get complete information about the functional design, economy and dependability of the NEW No. 5 JENSEN JACK. See your dealer or write JENSEN BROS., manufacturers of JENSEN JACKS for more than 36 years.

JENSEN JACKS

JENSEN BROS. MFG. CO., INC.
Coffeyville, Kansas, U.S.A.

Export Office:
25 Broad Street, New York City

Pumping Unit Foundation Is Moved, Altered Easily

Foundations of the type illustrated are being constructed by a producing company for various size pumping units. This sort of foundation allows the size pumping unit used on a well to be altered with comparative ease as well loads change. On small units the foundation can be moved with the pumping unit. If the unit is heavy, the foundation may be detached and moved separately.

To construct these foundations, a set of collapsible forms are used. Reinforcing bars, threaded at each end, are placed inside the forms and through their sides. Plates and nuts keep the form intact when cement is poured. A large steel plate equipped with a sturdy ring is placed at the front end. This provides a means of attaching a winch line securely to the foundation for moving purposes.

Stud bolts for tieing down the pumping unit are placed in a template which positions them at the top of the foundation. When everything is in place cement is poured. Once it is dry, the forms are removed.

comprehensive service covering

ENGINE TORQUE

For more than half a century, Clark Equipment has focused its engineering attention on a Vital Area of machinery performance —the Transmission of Engine Torque.

From that planned specialization came Clark axles, Clark transmissions and the Clark one-piece forged axle housing; and finally, as a natural evolution, the Clark torque converter.

Better Power-Trains=Better Machines

When the first Clark fork-lift truck was born in 1927, Clark applied its know-how and torque transmission experience to developing power-train systems for this new type of vehicle.

Again, in recent years, Clark developed a revolutionary power-train for its own newly developed tractor shovel; and almost overnight became a major factor in the construction machinery industry.

What could be more natural than that other manufacturers of agricultural and industrial machinery, recognizing Clark's unique asset of power transmission experience and expertness, should ask for Clark collaboration in developing driving units of functional design for their own products?—ask for it, and get it.

So today it can be said of many modern machines, Clark-built and others: "From engine flywheel to point of power use—torque transmission system designed and manufactured by Clark Equipment."

NOW: A Service to Users

Today that invincibly logical Clark development has an equally logical sequel: a complete Power Transmission Service to users of diesel or gasoline horsepower—from flywheel to point of torque application.

That service is implemented as follows:

- **District Sales Engineers—A nation-wide organization of men fully qualified to help solve technical problems**
- **Independent Equipment Dealers—Long established businesses of high reputation and well staffed; to distribute Clark products direct to users in certain key industries**
- **Adequate Service Facilities—With service parts stocks maintained at strategic points, to provide prompt, accurate satisfaction for users' needs**

As a user of diesel or gasoline horsepower, always on the lookout to get the best possible performance at lowest possible costs, you'll find it good business to establish a working relationship with Clark, through its nearest representative.

H. A. DAVIS

H. A. Davis Power Equip. Co.,
2142 Irving Boulevard, Dallas, Texas

In Texas, Clark's automotive line is handled by H. A. Davis Power Equipment Co., leading distributor, with complete sales, service and parts inventories.

JOHN M. SHANK

John M. Shank Co.,
5 Birchwood Ave.,
White Bear Lake 10, Minn.

Mr. Shank, power equipment veteran, distributes Clark automotive products in Minn., Wis., N. and S. Dakota, Iowa, Nebr., Upper Mich.; and maintains complete service facilities.

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Jackson 16, Michigan

Axles: Buchanan 5, Michigan

What's Happening

AMONG MEN IN THE INDUSTRY

David A. Carnahan

Guy R. Brainard

Drilling and Exploration Company, Inc., a Nevada corporation, announces the election of **David A. Carnahan** as vice president. He will be concerned primarily with foreign operations and will headquarter in Los Angeles. Carnahan's background includes experience with a major oil company and steel company prior to becoming chief engineer and then sales manager for a manufacturer of oil field equipment. He was promoted from chief engineer at Drilexco. **Guy R. Brainard, Jr.**, formerly vice president of Lucerne Corporation, also has been named vice president of the drilling and exploration company. Before joining Lucerne in 1951, he had been with Seaboard Oil Company as assistant manager of production.

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Maurice D. McBride retired recently after 37 years with **Tide Water Associated Oil Company** and subsidiary companies. His last position was as superintendent, secretary and a director of the East Jersey Railroad and Terminal Company, a Tide Water subsidiary.

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Dr. Sylvain J. Pirson, formerly a special research associate with Stanolind Oil and Gas Company in Tulsa, has joined the University of Texas petroleum engineering faculty. He will teach subjects concerning well-log interpretation and reservoir engineering, two areas which have been his special research interests. Pirson formerly has been special lecturer in petroleum engineering at the University of Tulsa, geophysics instructor at the Colorado School of Mines and petroleum engineering and geophysics professor at Pennsylvania State University. His book, Elements of Oil Reservoir Engineering, is used as a college textbook.

•

J. P. Badami has been promoted to the newly-created position of geophysical supervisor for **Continental Oil Company**, with headquarters at Durango, Colo. He formerly was a geophysicist for Conoco in Denver. It was announced at the same time that **Francis W. McWilliams** has been appointed assistant division land superintendent for Conoco, with headquarters at Casper, Wyo. He formerly was assistant division land superintendent in Denver. Badami joined Conoco's geophysical section in 1948. McWilliams joined Conoco in 1952. Before his promotion to assistant division land superintendent in Denver, he held a succession of positions in the company's regional and division land sections.

H. O. Heckert, contract representative for **Loffland Brothers Company**, has been transferred from Midland, Texas, to New Orleans and will be in charge of the New Orleans Contract division covering southeast Louisiana, Mississippi and Arkansas. Heckert joined Loffland Brothers in 1949, transferring to the Contract division in Tulsa in 1950. After 4½ years' service there, he moved to Midland where he was in charge of the company office.

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E. H. Rainwater, Shell Oil Company, has been transferred to the Technical Service division in Houston. He formerly was division stratigrapher in Jackson, Miss.

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I. L. (Steve) Schooler has been promoted to chief clerk for the Drilling department of the Morgan City, La., office of **Kerr-McGee Oil Industries, Inc.** Moving up to Schooler's former position as materials control chief in the company's headquarters in Oklahoma City is **George Ruster.** He formerly was assistant to Schooler.

•

Frank A. Morgan, for many years vice president and manager of exploration for Richfield Oil Corporation, has returned to Los Angeles after more than a year in Australia and the Far East. He will open engineering offices in the Roosevelt building in Los Angeles and will be associated with his son, **Frank A. Morgan, Jr.**, petroleum geologist of Casper, Wyo., specializing in petroleum exploration and development, domestic and foreign. Morgan resigned from Richfield in 1954. A director of Ampol Exploration Limited, Australia, he has been identified with the pioneering search for oil in Western Australia.

Frank A. Morgan

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S. C. Bowman has been appointed to the new position of manager, public relations, of **The California Company.** First with the company as traffic representative in 1946, he was promoted to supervisor of traffic in 1948. In 1952 he became training supervisor, the position he held until this recent promotion. Bowman will continue to be headquartered in New Orleans.

•

Tennessee Gas Transmission Company of Houston recently announced three personnel transfers and a new appointment in the Oil and Gas Exploration department. **R. C. Honea**, district exploration manager at Wichita Falls, Texas, has been transferred to a similar post in the company's district office in Midland, Texas. **J. M. Wolfe**, district geologist in Midland, has been shifted to Wichita Falls as district exploration manager. **L. B. Vaden**, formerly district exploration manager at Midland, has been moved to TGT's Houston office as staff landman. New appointee is **Richard H. Benish**, formerly geophysical and geological consultant in Denver who has joined TGT as geophysicist.

Tekoil Corporation and **The Saint Anne's Oil Production Company** stockholders have approved the merger of the two companies. Tekoil stockholders also elected **Fred W. Fairman, Jr.**, of Chicago, a director of the new company. A former member of the Saint Anne's board, Fairman is chairman of the board of Fairman, Harris & Company, Inc., investment bankers. **William J. Finch** of Midland, president of Saint Anne's, has announced that he will continue as an independent operator in West Texas. The new company which retains the Tekoil name, assumes operating control of producing wells in West Texas, New Mexico and Kansas. **Seth J. Abbott, Jr.**, has joined Tekoil as a petroleum engineer in the Dallas office. He will supervise the company's West Texas properties where water-flooding activity is now underway. Formerly with the Atlantic Refining Company as production engineer, Abbott has done research in flooding operations and techniques used in secondary recovery of oil. Prior to joining Atlantic, he was a petroleum engineer with the U. S. Bureau of Mines.

Fred W. Fairman

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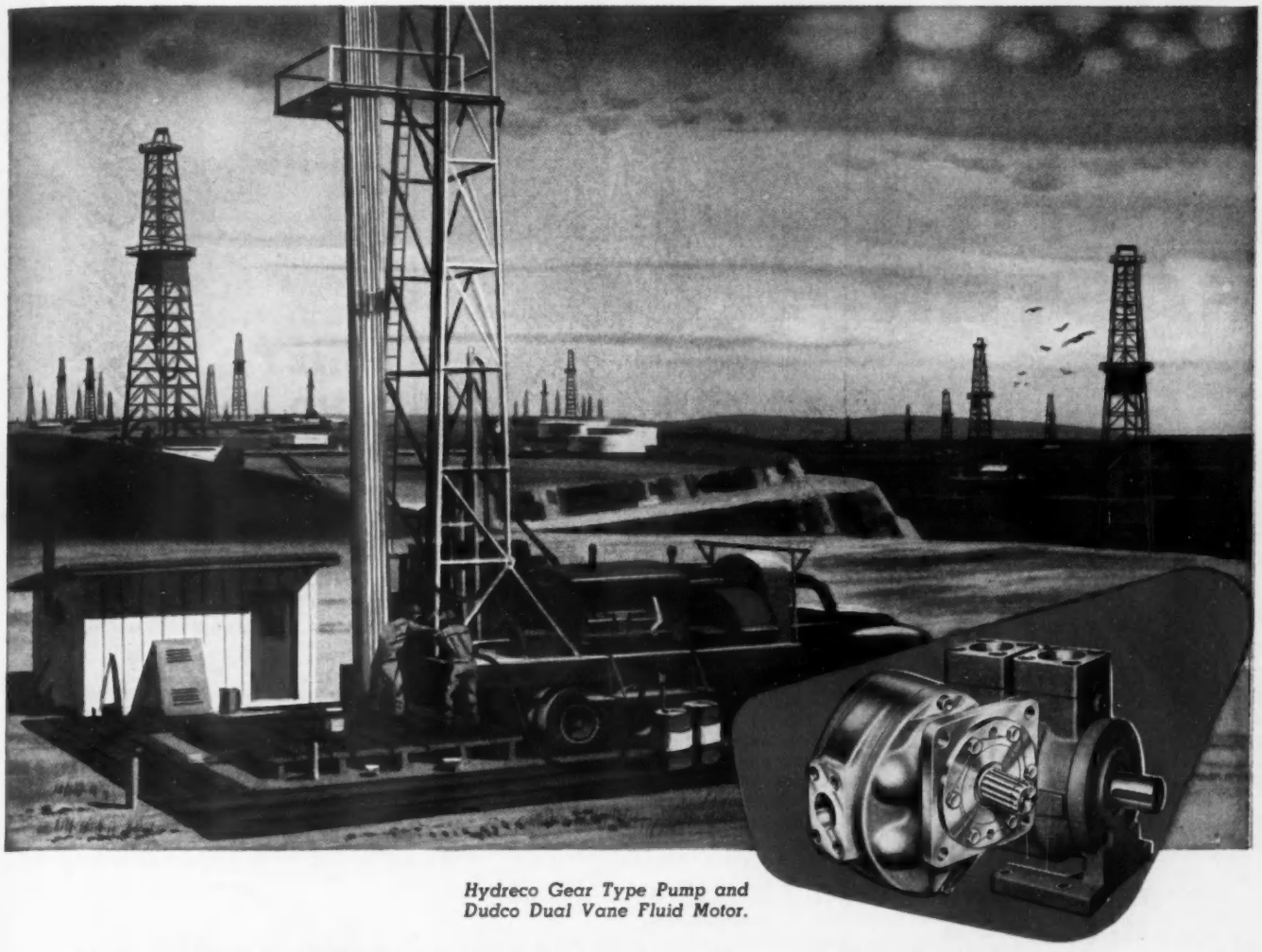
Freeport Oil Company has announced the following appointments: **J. M. C. Gaffron** has been named assistant to vice president, and **Carl Kearfott**, superintendent of drilling and production. **Paul Noll**, as assistant superintendent of drilling and production, will assist Kearfott. **R. M. Jemison, Jr.**, has been named district geologist. All four are of New Orleans. **G. B. McBride** of Midland, Texas, has been named superintendent of land and exploration, West Texas and New Mexico. Freeport Oil is a division of Freeport Sulphur Company.

•

L. G. Williams, formerly subsurface geologist at the Evansville, Ind., land and geological office of **Phillips Petroleum Company**, is now division geologist. He replaces **J. C. Smith, Jr.**, who moved to the Shreveport office with a promotion to assistant division manager and division geologist. Three promotions in the Wichita Falls land and geological office of Phillips have been announced. **O. M. Hudson**, formerly division geologist, has been appointed division manager; **J. H. Ball**, formerly division landman, has been appointed assistant division manager and division landman; and **F. H. Olson**, formerly assistant division geologist, has been made division geologist. **H. J. Tyler**, formerly division geologist at the Shreveport office has been promoted to division manager.

•

Jack R. Fraser is now senior petroleum engineer on the Dallas engineering staff of **Republic Natural Gas Company**, and **Dan N. Bailey**, a junior petroleum engineer in the Hugoton district. Fraser formerly was with Shell Oil Company and Texas Eastern Production Company. Bailey is a petroleum engineering graduate from the University of Texas.



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Edd Riddle, Jr.

T. Wayne Hurt

Nolan Hirsch

Cecil Aycock

Texas Pacific Coal and Oil Company's Exploration department has announced the following promotions: **Edd Riddle, Jr.,** has been named Midland division exploration manager, in charge of the land and geological work in the West Texas and New Mexico area. Riddle is being transferred from the Canadian division where he has been serving as exploration manager. **T. Wayne Hurt,** former assistant in the Canadian division, succeeds Riddle as manager. **Nolan Hirsch** is advanced from district geologist in Midland to chief exploration and development geologist in the Fort Wortth home office. **Robert L. Porter,** former Abilene subsurface geologist, replaces Hirsch. **Cecil Aycock,** former assistant to Hirsch, becomes district geologist in the Midland district. **Billy J. Moore** continues as head of the Midland land department.

•

R. L. Lay, formerly assistant to the vice president of **The Texas Company's** Domestic Producing department, recently was appointed assistant to the vice president in charge of operations in the Eastern Hemisphere. **J. H. Rambin, Jr.,** assistant general manager of the Domestic Producing department in Houston, will assume Lay's former post in New York City.

•

Douglas R. Keenan, Jr. has joined the staff of **Gulf Coast Leaseholds, Inc.** as exploitation geologist. He was formerly a senior geologist on the staff of Sinclair's Gulf Coast division. In 1949 he was with the Gulf Oil Corporation as a geologist in the reserve section. He went to American Republics in 1951 as a reserve geologist, transferring to Sinclair when American Republics was purchased by that company.

•

Paul R. Warren has been promoted to regional geologist for **Continental Oil Company's** Central region. Formerly assistant regional geologist, he will continue to make his headquarters in Oklahoma City. Warren joined Conoco in 1933 as a geophysicist and served on seismograph crews in several states before his promotion in 1946 to geophysical supervisor. He became regional geophysicist at Oklahoma City in 1950 and assistant regional geologist two years later.

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Fred H. Moore, assistant to the president of **Magnolia Petroleum Company**, will become executive vice president and manager of Mobil Oil of Canada, Ltd., with headquarters in Calgary. The advancement is effective April 1. Moore succeeds **H. R. Moorman**, who is being moved to Socony Mobil's general offices in New York. Magnolia and the Canadian organization are both affiliates of Socony Mobil Oil Company, Inc. Moore joined Magnolia in 1935 as field geologist in Oklahoma. After working in oil fields in Texas, New Mexico, Kansas, Ohio and Illinois, he became a staff geologist in the Dallas headquarters. In 1951 he was appointed assistant to the president.

Fred H. Moore

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Serge B. Jurenev has been promoted to assistant to the president and chief economist for **Continental Oil Company**. Formerly assistant to the chairman of the board of directors, he will continue to make his headquarters in New York. Jurenev joined Continental in 1942 and two years later became secretary and assistant treasurer. He was promoted to secretary and treasurer in 1948. He assumed charge of the Coordinating and Planning department in 1949 and the following year transferred to the company's executive offices in Houston, returning to New York in 1953 as assistant to the chairman.

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Sun Oil Company announces the appointment of **Raymond Higgins** as manager of the newly-formed Aviation department, organized to coordinate responsibility for the firm's aviation facilities and flying personnel. Higgins, who has headquarters at the general offices in Philadelphia, has been chief pilot for Sun since 1946. As manager of the department, he will be responsible for development of standards for selection of aircraft; for operating procedures; and for selection and training of aviation personnel.

•

G. Dewey Thomas' appointment as area geologist in **Shell Oil Company's** New Orleans exploration and production area, has been announced. Thomas, who has been geologist for special problems in the Shreveport exploration division, succeeds **James B. Dorr**, now on special assignment in the area office. Thomas joined Shell as an assistant geologist at Shreveport 31 years ago. Subsequently stationed at St. Louis, Mo., Evansville, Ill., and Dallas, Texas, he returned to Shreveport in 1937. He became senior geologist there in 1945 and was assigned to special problems in 1951.

•

Craig Norton, formerly petroleum engineer with Superior Oil Company, recently joined the staff of **Wm. Ross Cabeen and Associates** and will headquarter at the Denver office of the firm. Although he will engage principally in evaluation and reservoir work, Norton also will supervise drilling and production activities for Cabeen Exploration Corporation and other associated companies.

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(For more data on advertised products, use Readers' Service blue cards, last page this issue.)

J. E. Roth has been appointed administrative vice president for production, **Tide Water Associated Oil Company.** In his new post, with headquarters in San Francisco, he will be responsible for planning and coordination of all Tide Water production activities. With the company since 1924, Roth has served as general manager of the Central division, with headquarters in Tulsa, since 1954. **Charles R. Brown,** vice president, has been named general manager of the Central division, succeeding Roth. Brown, who has been with the Tide Water organization since 1917, was named vice president in 1948 and became assistant general manager of the company's West Coast operations in 1954. He was made assistant general manager of the Central division in 1955.

Gibraltar Oil Corporation announces the association of **W. W. Griffith, Jr.,** as division engineer in the West Texas headquarters in Midland. In the production and drilling engineering sections of Atlantic Refining Company the last nine years, his experience has been extensive in areas in which Gibraltar now operates and plans to expand. Gibraltar maintains West Texas offices in the Leggett building in Midland.

W. W. Griffith

Nelson Puett's appointment as chairman of the **Federal Petroleum Board** at Kilgore, Texas, on recommendation of Assistant Secretary Felix E. Wormser and H. A. Stewart, director of the Office of Oil and Gas, has been announced by Secretary of the Interior Douglas McKay. **Leo Hart** resigned as chairman of the Federal Petroleum Board in February. Puett, who heads the board responsible for administering the Connally Act under supervision of the Office of Oil and Gas, has over 15 years' experience as an examiner in Connally Act administration work and has been a member of the Federal Petroleum Board since 1952. Before entering Federal service, Puett was engaged in private law practice in Texas for more than 20 years, eight years specializing in oil litigation and oil problems.

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Orville G. Lundstrom has resigned as district geologist with the Houston Oil Company to join **North Central Oil Corporation** as geologist for the state of Texas. North Central recently was organized to purchase all properties of The North Central Texas Oil Company, Inc., of Shreveport, La. The new company has established headquarters in the Sterling building in Houston. District offices are maintained in Lafayette, La., with **Jack Phillips,** formerly with Cities Service Oil Company, in charge. Other officers of North Central Oil are **Gilbert Kerlin,** president; **John Wemple,** vice president and general manager; and **E. L. Norton,** vice president and treasurer.

O. G. Lundstrom

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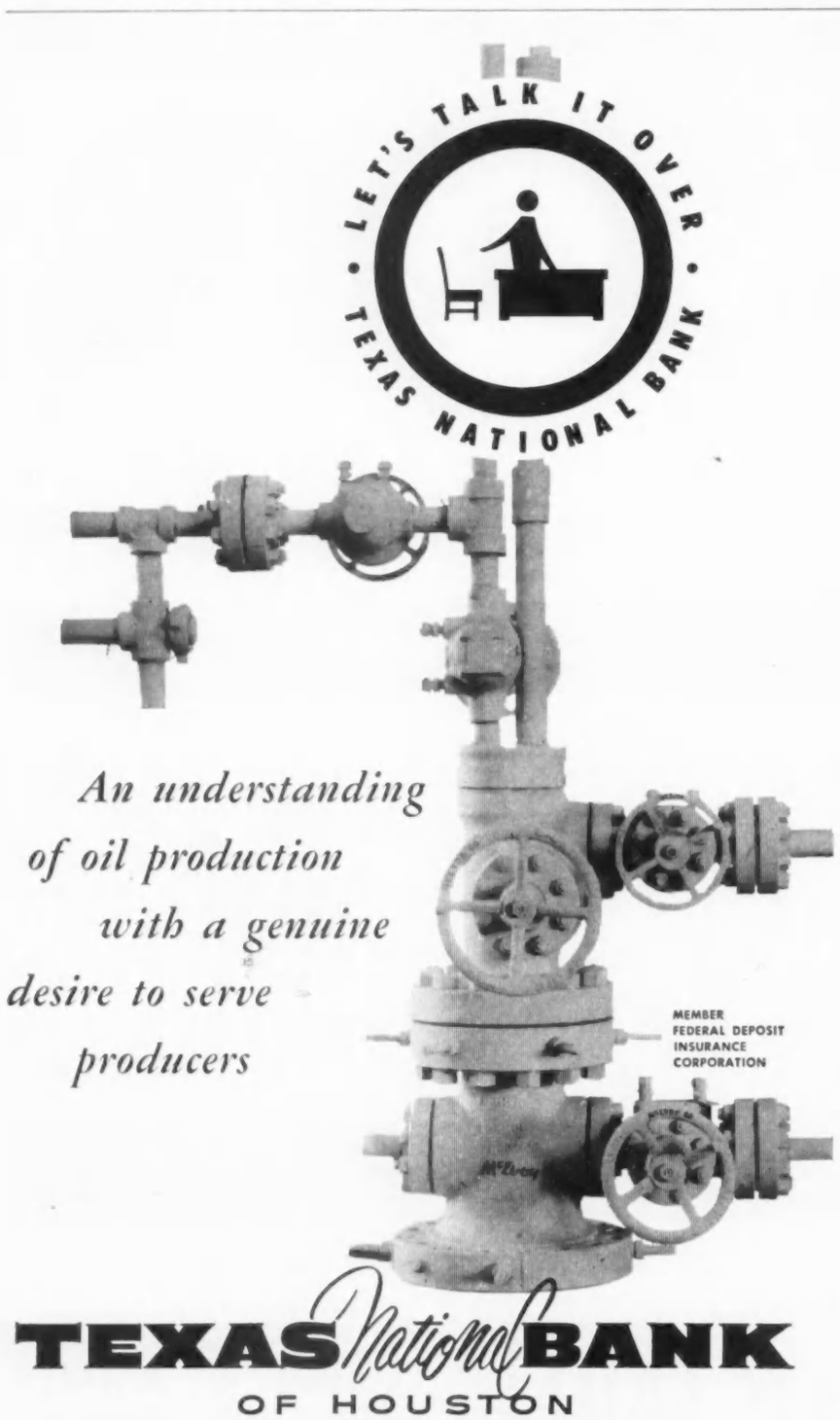
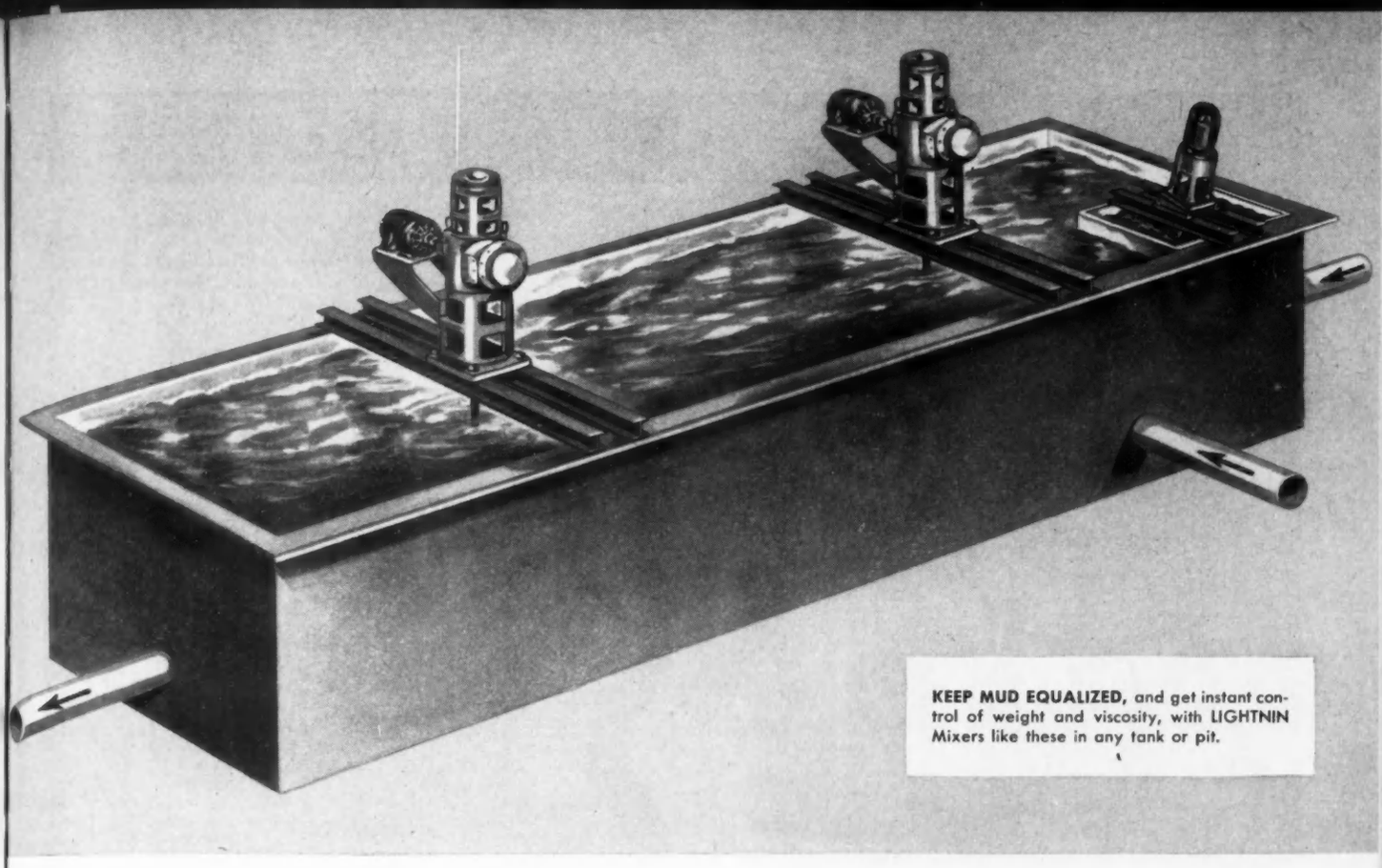
The CATC Group announces the appointment of seven men to a new marine region which will be headquartered in Houston. It will serve as operator for the CATC Group consisting of Continental Oil Company, Atlantic Refining Company, Tide Water Associated Oil Company and Cities Service Oil Company. Formerly administered by Conoco's Offshore Marine department, the CATC Group's expanded operations recently required formation of a separate region. Conoco's offshore activities other than CATC will become a part of the company's Southern region Exploration and Production departments. The CATC region men, all of whom will be headquartered in Houston, are **S. V. McCollum,** Fort Worth, assistant production manager of Conoco's southwestern region, promoted to production manager for the CATC marine region; **John H. Davis,** Houston, offshore division exploration manager, promoted to CATC marine region exploration manager; and **W. A. Pearce,** Houston, formerly section chief in Conoco's headquarters Production department, promoted to CATC regional engineer. **H. A. McKinley,** Houston, offshore division land superintendent, was promoted to CATC marine region land superintendent; **R. M. Dungan,** Houston offshore division geologist, was promoted to regional geologist for the CATC marine region; **D. F. Wint,** Houston, formerly offshore division geophysicist, was named regional geophysicist for the CATC marine region; and **M. J. Lindsay,** Houston, offshore division chief clerk, was made CATC regional chief clerk.





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3. You can cut operating costs with LIGHTNIN mud control. You eliminate the cost of abrasive wear-and-tear on mud guns, valves, pipe, and fittings.

You save mud pump capacity, too. None of your pumps are used for mixing. You eliminate wear-and-tear on the standby pump. On deep holes, you save the entire cost of a third mud pump, and as much as 90% of the cost of replacement parts for it ($180 to $450 per month).

You use less power for mixing. And you can use electric, steam, or gasoline power to drive LIGHTNIN Mud Mixers.

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DEATHS

Chester House, 64, Oklahoma oil well driller, died January 14. He was active in early Oklahoma oil field developments and was employed in the Nowata fields prior to his death.

Tom Thompson Hawksworth, 57, died January 22 in Paris, Texas. He established Hawksworth Oil, Inc. in Tulsa about a year ago.

Harold B. Bernard, 62, retired Tulsa oilman, died January 29 in Tulsa. With Sinclair Oil and Gas Company many years before his retirement in 1935, he specialized in building and operation of gasoline plants. He became a vice president of Sinclair at the age of 30 and for a time was president of one of their subsidiary firms.

Del Howard, consultant in Dallas, died January 27. Formerly in Oklahoma with Cities Service as gas engineer, he also was with Republic Natural Gas. He went into consulting work two years ago.

Neil Jackson Norris, Sr., 75, pioneer oilman, died recently in Los Angeles. He retired in 1945 as vice president of Bell & Loffland, Inc.

Dennis F. McCarthy, 67, former vice president and general manager of A. O. Smith Corporation of Texas at Houston and a former manager of A. O. Smith's Tubular Products division at Milwaukee, died February 5. He had been with the firm since 1936, serving on the president's staff ten years before becoming head of the Tubular Products division when it was formed in 1947.

A. O. Rankine, 74, professor of physics at the Imperial College of Science and Technology, London, died recently in London. With Anglo-Persian Oil Company (now British Petroleum Company, Ltd.) more than 25 years, he was geophysical advisor from 1927 to 1937 when be became chief physicist. He retired from the company in 1952.

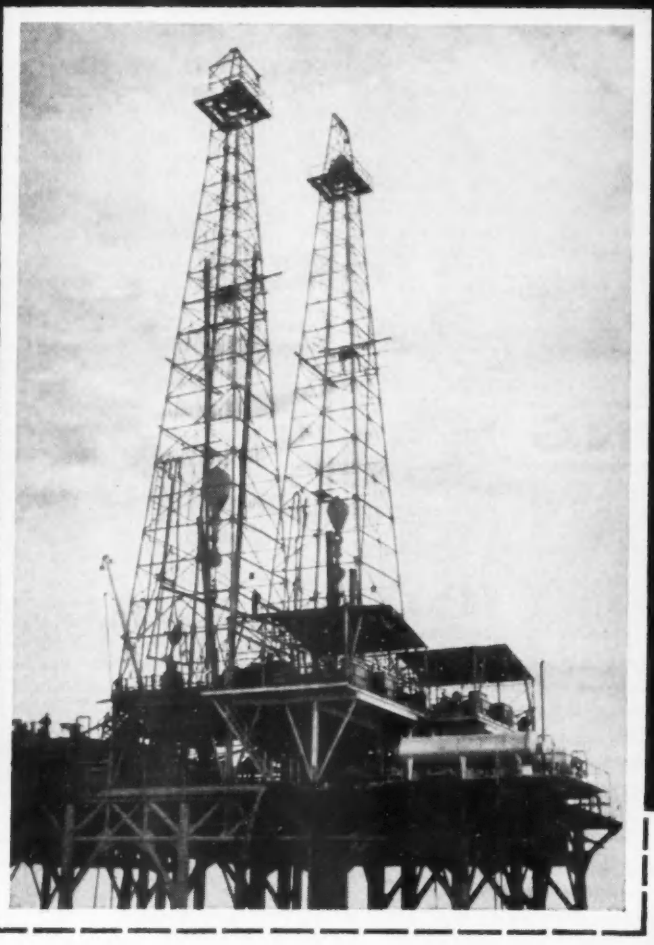
Rev. James B. MacElwane, 73, world famed seismologist who established at St. Louis University the first department of geophysics in the Western Hemisphere, died February 15 in St. Louis. Dean of the St. Louis University Institute of Geophysical Technology, Father MacElwane also pioneered in geophysical oil exploration.

H. S. Woolner, 88, died February 5 in Long Beach, Calif. He was president of America Oil Corporation and Woolner Corporation.

H. A. Flannery, 61, manager of engineering for the Goodyear Tire & Rubber Company since 1935, died recently in Akron, Ohio. He was responsible for planning and supervising construction of manufacturing plants and other properties of the worldwide Goodyear organization.

William David Steinle, 40, died February 20 in Tulsa. He was assistant Oklahoma division petroleum engineer of The Texas Company's Producing department.

(For more data on advertised products, use Readers' Service blue cards, last page this issue.)



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Companies in the News

CITIES SERVICE COMPANY recently announced plans for a capital expenditure program for 1956-1960 of $750 million to be used principally for expanding search for oil and gas reserves in the U. S. and in foreign areas. The program also provides for substantial new activities and additions to facilities in manufacturing, research, transportation, marketing and petrochemical phases of the oil and natural gas industry. Capital expenditures for 1956 will amount to $135 million, the largest portion of which will be directed toward a substantial increase in the company's exploration program.

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SHAWNEE OIL COMPANY has been formed in Denver by Frank O. Prior, Jr., Robert E. Chancellor and I. J. Gefroh. The new firm will operate in the Rocky Mountain area and will concentrate mainly in the Denver-Julesburg basin.

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1" to 4"—Seamless
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⅛" to 4"—Seamless
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Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo.—Earl H. Jones & Co., 1863 Wazee St.
Detroit, Mich.—R. W. Lang, Jr., 505 Park Avenue
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Houston, Tex.—Henry H. Paris Distributor, Inc. Box 932
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Ave.
Louisville, Kentucky—Sid. Schultze Co., 514 W. Main St.
Milwaukee, Wisconsin—M. A. Nelson Co., 3347 N. 97th St.
Minneapolis, Minn.—Lin J. Krause, 5605 Lyndale Ave. S.
Narberth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Ira L. Rothenberg & Assocs., Industrial Office Bldg., 1060 Broad St.
New York, N. Y.—Max Rothenberg, 11-05 38th Ave., Long Island City
Oswego, N. Y.—Northeastern Associates, Neil Chatterton, Secy., P. O. Box 284
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
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WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
Factories at WHEELING, W. VA. and WOODLAKE, CALIFORNIA

SOCONY MOBIL OIL COMPANY, INC., recently announced plans to contribute $672,770 to higher education in the U. S. and Canada in 1956. The money has been allocated as part of the company's program of assistance to universities and colleges. An additional $250,000 increased the original allocation to the present sum to include grants to private liberal arts institutions. Remainder of the money is detailed for fellowships, $68,000; scholarships, $61,000; and research and other grants, $293,770. In addition to the grand total, the company has allocated $32,000 for incentive fellowships for employes and $67,700 for the American Petroleum Institute to further its program of fundamental research and special projects carried out in various colleges. Grants basically cover all fields of collegiate and graduate education as well as aid to libraries, museums, societies and miscellaneous projects.

•

GRAHAM DRILLING COMPANY, newly-formed firm, will engage in contract drilling of oil and gas wells in California, Oregon and Washington. **Gene Graham** is president of the new concern; headquarters will be in Los Angeles with offices in the Subway Terminal building. Graham was executive vice president and a member of the board of directors of the Thomas P. Pike Drilling Company until its recent sale to Republic Supply Company.

•

DAVIS BROS., Tulsa, has purchased all mineral interests of the Foundation Oil Company in Colorado, Nebraska, Illinois, North Dakota and Texas. The purchase which also includes partial mineral interests in approximately 15,000 acres, was made in the name of New Era Royalties Company.

•

PADRE DRILLING COMPANY has been formed in Corpus Christi, Texas, with **Tom Billings** as manager. The firm has one portable drilling rig and has completed two wells in the Port Lavaca area.

•

PAN AMERICAN PRODUCTION COMPANY has established a new section in the Houston office for coordination of all matters pertaining to jointly-owned operations in which the company participates. **H. L. McDonald** has been appointed co-ordinator-Joint Interest Operations. He and his staff will be responsible for coordinating all matters pertaining to joint operations with other producers.

•

PRODUCING PROPERTIES, INC. recently announced acquisition of a working interest in 14 leases from Lucerne Corporation of Dallas. The leases on which are located 76 producing wells are in Dequincy field, Calcasieu Parish, La.; Dyersdale field, Harris County, Texas; and North Thompson field, Fort Bend County, Texas. Total consideration was $1.2 million.

What's Happening

AMONG INDUSTRY ASSOCIATIONS

Link to Head AAPG As 1956 President

Theodore A. Link will become the fortieth president of the American Association of Petroleum Geologists when he assumes executive responsibilities of the organization April 26 at the close of the annual meeting being held in Chicago. Link is president of Link, Downing & Cooke, Limited, petroleum consultants of Calgary, Alberta, and Toronto, Ontario, Canada.

Also on the 1956-57 executive committee of the geological organization will be G. M. Knebel, manager, Exploration division, Standard Oil Company (N. J.), past president; Ben H. Parker, president and director of Frontier Refining Company, vice president; and W. A. Waldschmidt, consulting geologist of Midland, Texas, secretary-treasurer. Editor of the AAPG monthly *Bulletin* will be W. C. Krumbein, professor of geology, Northwestern University.

Retiring members of the Executive Committee are past-president Edward A. Koester, consulting geologist, and vice president Horace D. Thomas, director and state geologist, Wyoming Geological Survey, and professor of geology at University of Wyoming. Waldschmidt and Krumbein have been elected to a second term.

Link, who became a member of the association in 1920, has been a member of the Business Committee, an associate editor from 1935 to the present, a member of the Research Committee, a distinguished lecturer and was vice president of the association in 1950-51.

Tulsa Nomads Officers Inaugurated

Shown at the Fifth Annual Inaugural Ball following their installation as 1956 officers of the Tulsa Chapter of Nomads are: left to right, front row, Gilbert Swift, senior regent; R. C. Glover, past senior regent; Don L. Collins, president; H. M. Cooley, master of ceremonies; Cecil C. Crider, vice president; and Guy F. Williams, treasurer. Left to right on second row are Oscar Irizarry, secretary; John Pearce, assistant secretary; E. J. Handley, sergeant-at-arms; and W. O. Timberlake, deputy sergeant-at-arms. Officers not shown include Jack H. Beesley, junior regent, and Paul V. McGivern, assistant treasurer.

API General Committee OK's Drilling Report Form

Climaxing four years' work by special committees, the General Committee of the American Petroleum Institute's Division of Production has approved the revised Daily Drilling Report form.

To benefit both operators and contractors, the form is designed to save time by requiring the driller to fill out only one report; to speed up payment of "day work" invoices by eliminating controversies caused by errors made at the rig when filling out two reports; to encourage more complete and accurate reports as drillers become familiar with one standardized form; and to provide adequate information for analysis of daily drilling operations by management.

A previous form was given tentative approval by the board of directors of American Association of Oilwell Drilling Contractors in 1953; the API General Committee tentatively approved the form in 1954. After this form had been in use almost 18 months, it was reviewed by committees of both groups, revised and finally adopted. Reruling to provide more space for time breakdowns for invoicing and checking; and two changes to embrace the value of engineering data brought about final approval.

Honorary Award Given SEPM Charter Member

Dr. Raymond Cecil Moore, University of Kansas, has been elected an honorary member of the Society of Economic Paleontologists and Mineralogists. One of three living SEPM members to be so honored, he will be presented an honorary membership certificate during the society's thirtieth annual meeting in Chicago April 23-26.

A noted teacher and author, Moore has been editor of the AAPG *Bulletin* and SEPM's *Journal of Paleontology* and *Journal of Sedimentary Petrology*. Since 1948 he has organized and directed the Treatise on Invertebrate Paleontology. Moore was a founder of the AAPG, was a charter member and former president of SEPM, is a fellow of the Geological Society of America, a former president of the Paleontological Society, and a member of the American Association for the Advancement of Science and Kansas Geological Society.

Houston Nomads Name 1956 President

Nomads and guests greeted the new administration of Houston chapter president W. O. (Bill) Hedrick at a recent meeting in Houston. Warren Baker, editorial director of WORLD OIL, was main speaker for the evening, presenting a forecast on oil industry activity for 1956. Nomad guests attending the meeting were: seated, left to right, Bill Boren, Rolo Manufacturing Company; W. B. Jeter, Hardy-Griffin Company; H. R. Stephen, National Supply Company; Warren Baker; Jorge T. Lavandez, Coper Ltd., Lapaz, Bolivia; Gene LaSchober, Jr., Bethlehem Steel Company; George R. Grim, Jr., Manabi Exploration, Ecuador; and Dewey Clark, Southeastern Asia Drilling Company. Standing, left to right, W. O. Hedrick; F. B. Allary, Cameron Iron Works; J. M. Gray, McCullough Tool Company; John Hardy, Hardy-Griffin; Cecil Smith, Gulf Publishing Company; B. Stark, Cameron Iron Works; Fred Buckner, B-J; E. O. Koberg, B-J; Eduardo Rugamo, Mexico D. F.; Horacio de la Concha, Cameron Iron Works; and Stan Kazar, Hutchison Manufacturing Company.

API Southern District Hears Gulf Coast Problems

Problems and practices peculiar to Gulf Coast oil operations were examined at the Southern district meeting of the Division of Production of the American Petroleum Institute. The meeting, held in March in San Antonio, was the first formal gathering of the Southern district, formed late in 1955 from part of the former Southwestern district so that members could concentrate on Gulf Coast problems.

The new district comprises the Texas and Louisiana Gulf Coasts, southwest Texas, East Texas and the Arkansas-Louisiana-Texas area.

Among the papers heard by the some 900 oil men in attendance were The Challenge of Drilling Costs, Marine Safety on the Outer Continental Shelf, Automatic Production Controls, Report on Hydraulics of Rotary Drilling, Use of Helicopters in Offshore Drilling and Production Operations, and Directional Drilling as Applied to Salt Dome Oil Production in the Gulf of Mexico.

Max Genet to Manage Oklahoma Oil Association

Effective January 15, Max Genet, Jr., was named manager of the Oklahoma Independent Petroleum Association in Oklahoma City, succeeding S. M. Anderson, Jr. Anderson resigned to devote full time to his oil operations. Genet formerly headed the Oklahoma Well Log Exchange.

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Veteran Field Manager Retires from IPAA Service

Charles Van Vleck retired March 1 as field manager of the Independent Petroleum Association of America after almost 20 years' service. Named manager of the newly-created field department in 1936, he traveled extensively throughout the country, creating interest in the organization, gaining members, conducting meetings and maintaining contact between the home office and directors, now located in practically all states.

Van Vleck will resume his leasing, drilling and producing activities.

Leibrock Is New Chairman Of Wetsern AIME Section

R. M. Leibrock, of Leibrock and Landreth, Midland, is new chairman of the Permian Basin section of the American Institute of Mining and Metallurgical Engineers. Serving with him as vice chairmen are M. W. Russell, Dowell Incorporated, and W. L. Crothers, Humble Oil & Refining Company, also of Midland. R. M. Hippard, Shell Oil Company, Odessa, is secretary-treasurer.

R. K. Franklin Named National Nomads Chief

R. K. (Bob) Franklin of Houston, president and founder of Rolo Manufacturing Company, has been named chairman of the national board of regents of Nomads, National Oil-Equipment Manufacturers and Delegates Society. Succeeding James D. Hughes of Lane-Wells in Los Angeles, Franklin assumed office March 1. He is a former national regent of Nomads, past president of the Houston chapter, national member of the American Petroleum Institute and AIME.

W. L. Childs, Jr.

Nomads national board of regents also announced that W. L. (Bill) Childs, Jr., Reed Roller Bit Company, has been elected secretary-treasurer of the organization for the year beginning March 1. Sales manager of his company since 1952, Childs has been active in Nomads since 1946, serving as president of the Houston chapter and as junior regent for 1956.

API Production Division Schedules Denver Meeting

More than 700 producers will join in the meeting of the American Petroleum Institute's Rocky Mountain Division of Production in Denver April 18-20. Members will be drawn from Colorado, Utah, Wyoming, North Dakota and Canada.

API committees conferring during the meeting include Committee on Supervisory Development, Committee on Drilling Practices, Committee on Straight Hole Drilling, Committee on Blowout Prevention, Committee on Jet Bit Drilling and Hydraulics and others. General economics of the industry also will be featured part of the meeting program.

Claude E. Peavy, regional manager at Denver for Phillips Petroleum's Production division, is general chairman for the session.

What's Happening

AMONG SERVICE AND SUPPLY MEN

R. T. Stewart

A. G. McNeese, Jr.

Turgut Ulug

S. W. Collins

Allan B. Spurney

Roger Northup

Harrisburg Sales & Service, Inc., recently announced promotion of **R. T. Stewart** to district manager, with headquarters in Houston. He will be responsible for sales and activities in south and East Texas. At a new location for Harrisburg at Casper, Wyo., **B. C. McBride** represents the organization as sales engineer. Also announced as new sales engineers for the organization are **D. R. Glosson** in Houston, **Charles Cook** in Odessa, Texas, and **J. R. Floyd** in Oklahoma City. Stewart, who has been with Harrisburg Sales & Service in Houston since 1948, formerly was employed by an oil field supply company.

A. G. McNeese, Jr., succeeds **L. R. Bryan, Jr.**, as president of the Second National Bank of Houston, now the **Bank of the Southwest.** Bryan was advanced to vice chairman of the board and chairman of the Executive Committee by recent action of the board of directors. McNeese at one time practiced law with Price & Smallwood, moving in 1939 to Fulbright, Crooker, Freeman, Bates & Jaworski. In 1943 he became vice president and general counsel of the McCarthy Oil & Gas Corporation, where he stayed until 1951 when he was named executive assistant to the president at Houston Oil Company of Texas. He was elected assistant president of the Second National Bank in 1953. In other promotions, **Lloyd M. Bentsen, Jr.**, was named to the board's advisory committee and **William B. Black Jr.**, and **Newton Wray** were made vice presidents. Bentsen is president of Consolidated American Life Insurance Company. Black and Wray formerly were assistant vice presidents in the Business Development department.

Turgut Ulug, a Texas-trained petroleum engineer with ten years of service with the Turkish government and three years with a Canadian oil company, has joined the technical service staff of **IDECO**, one of the Dresser Industries. After completing a study of new equipment designs and production techniques at IDECO's Beaumont, Texas, plant, he will establish sales headquarters in Calgary, Canada. Ulug worked with the Turkish Government M.T.A. Institute for ten years as drilling engineer, as chief equipment engineer and as assistant manager of petroleum operations. In 1953 he became drilling engineer for Hudson's Bay Oil and Gas Company in Calgary.

Warren M. Benson, vice president of **Alten Foundry & Machine Works, Inc.**, announces the appointment of **S. W. (Sandy) Collins** as the Alten representative in the Indiana-Illinois-western Kentucky area. Collins has been active in the petroleum industry since 1930, his experience including field and supply store sales as well as district and regional sales positions.

Pacific Pumps, Inc., has announced the appointment of **Allan B. Spurney** to the newly-created position of manager of foreign operations. Spurney will direct the firm's international activities and its relations with those European companies manufacturing Pacific products under license. The Pulsometer Engineering Co. Ltd., Reading, England; Batignolles-Chatillon, Paris, France; and Koninklijke Machinefabriek Gebr. Stork & Co., Hengelo, The Netherlands.

Roger Northup, new vice president of **United Supply Company**, will supervise the company's Texas-New Mexico operations out of Dallas, with offices in the Fidelity Union Life building. Northup joined United Supply in 1941. His 15 years' field experience also included service in Odessa and Midland.

Oil Base, Inc., announces the appointment of **Charles Allen** as sales and service engineer, to work in the Los Angeles Basin area with headquarters at Long Beach, Calif. Allen, formerly with Petroleum Engineering Associates in charge of fluid logging, joins the company after seven years' oil field experience. **Joe King** has joined Oil Base in Bakersfield to cover the San Joaquin Valley as sales and service engineer. His experience has been in the drilling and production phase of the business with mud experience over a period of several years.

H. C. Smith Names Officers

New officers and directors of the H. C. Smith Oil Tool Company were elected at the recent annual meetings of stockholders and directors. Shown seated, left to right, are: Herschel C. Smith, executive vice president; Herman C. Smith, president; Donald E. Graham, vice president-operations and secretary. Standing, left to right: Arthur S. Marshall, vice president-sales; Robert L. Flynne, vice president-finance and treasurer; Kenneth H. Swart, vice president-engineering; and Franklin L. Stamm, director. Herman C. Smith, Herschel C. Smith and Marshall were reelected directors. Graham, Flynne, Swart and Stamm are newly-elected members of the board. Stamm is head of F. L. Stamm & Associates, management consulting firm.

(For more data on advertised products, use Readers' Service blue cards, last page this issue.)

John C. Butler

William W. Sentell

W. F. Raynolds

J. R. Sims

William G. Sharp

Edward A. Dunn

John C. Butler, recently named sales representative for **Oil Center Tool Company,** will work out of the Lafayete, La., branch. He formerly was with Continental Supply Company and Oil Well Supply Comany.

William W. Sentell, who has been a sales engineer in the compressor sales division of **The J. B. Beaird Company, Inc.,** ten years, has been promoted to assistant sales manager of the division. He has been with Beaird since creation of the division. **W. F. Raynolds** has been transferred as sales engineer from the Midland district to the Tulsa area formerly served by Sentell; and **J. R. Sims,** formerly general manager of a Shreveport engineering service company, has joined the Beaird compressor sales division as sales engineer for the Midland district.

Continental Supply Company has announced the appointment of **William G. Sharp,** former manager of the New Orleans district, as manager of Venezuelan operations. He is succeeded as district manager by **Edward A. Dunn,** former sales engineer for that area. Sharp, who will headquarter in Caracas, will have supervision of stores at Anaco and Lake Maracaibo in Venezuela, as well as other areas of northern South America. He joined Continental in 1947 and has since held positions as field salesman, store manager and assistant district manager. Dunn, who joined Continental in 1946, has held positions as field salesman, city salesman and sales representative.

Deane Courtright has been appointed district sales representative for **Leschen Wire Rope Division,** H. K. Porter, Company, Inc. His territory includes the state of Washington, northern and western Idaho and Montana. Courtright joined the Leschen organization in its Denver district.

J. H. Knecht's appointment as western sales representative for the **George E. Failing Company** has been announced. He formerly was with Emsco Manufacturing Company and Republic Supply Company. Knecht's territory for Failing will include California, Oregon, Washington and Nevada.

Robert S. Sherwood is advanced to manager of engineering at **Worthington Corporation's** Steam Turbine division. Formerly assistant director of research, he joined the company in 1951 as consulting engineer.

Elbert M. Palmer will succeed **Wm. Bradford Russell** as president of the **Kewanee Boiler Division** of American Radiator & Standard Sanitary Corporation. Russell is retiring from active service with the division but will continue to assist in a consultive capacity. Prior to his appointment, Palmer was executive vice president of the division. He began his career with Kewanee Boiler Corporation in 1926.

R. J. MacBean and **T. J. Moroney,** both vice presidents and trust officers of the **Republic National Bank of Dallas,** recently were elected vice presidents and senior trust officers. Both are veteran members of Republic's official staff, and have long held top positions in the Trust department.

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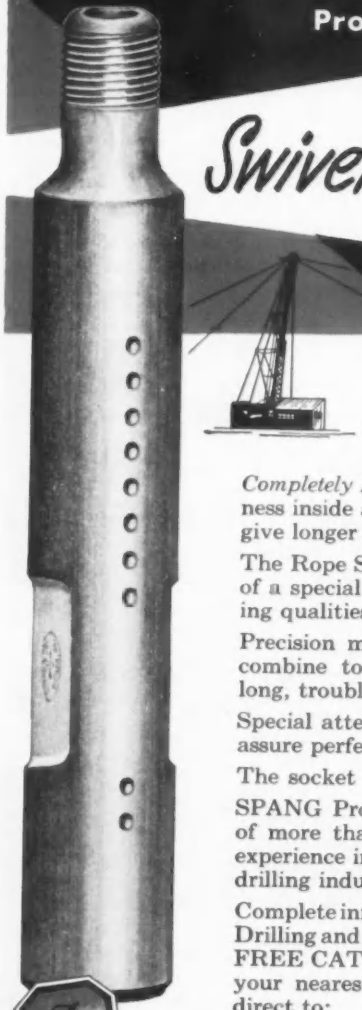

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William B. Ilko

Joseph W. Basista

John Sulton, Jr.

J. H. Newton

William B. Ilko has been appointed administrative assistant to Henry Ervin, vice president and director of sales, **American Chain & Cable Company, Inc.** Prior to joining the company, Ilko was general sales manager of the Simonds Abrasive Company, having started with that company in 1928. His headquarters with American Chain and Cable will be in New York City.

Joseph W. Basista, Goodyear Tire and Rubber Company petroleum sales, was honored recently commemorating 30 years' continuous service with the firm. He joined Goodyear in 1925, beginning his lengthy career as a sole and heel salesman in Atlanta, Ga. Assigned as a truck tire field representative in 1943, Basista moved to Indianapolis as a special petroleum representative a year later. He moved to Chicago as truck and bus representative in 1947. He was assigned his present duties in 1950.

John Sulton, Jr., has joined the **Frank Wheatley Supply Company** as a sales engineer. He formerly was district sales manager of the Nelson Electric Manufacturing Company, having been with them since 1950.

J. H. Newton has been appointed sales manager of the White Diesel Engine division of the **White Motor Company** after being in heavy duty diesel engine sales 19 years. He joined White's Diesel Engine division sales activity in 1948, after 12 years' association with Fairbanks, Morse & Company.

James D. Divelbiss has purchased from **Milt Collum** and **Wes Morgan** an interest in **Petroleum Geophysical Company** of Denver. Divelbiss was formerly with The Chicago Corporation as chief geophysicist. He will be in charge of operations for Texas, Louisiana, Oklahoma and all southeast U. S. with offices in The Continental Life Building, Fort Worth, Texas. Collum and Morgan will continue to operate out of Denver.

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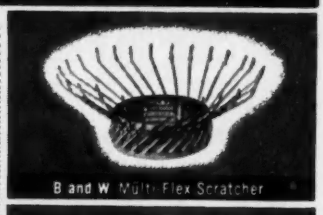

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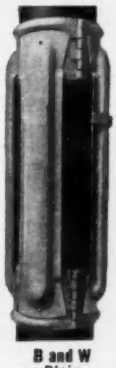
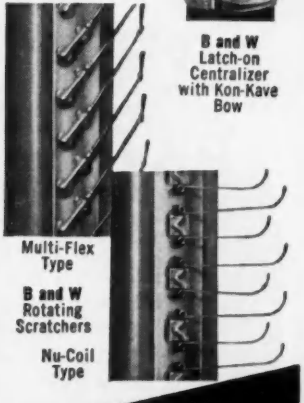


B and W Plain Stabilizer

B and W Latch-on Centralizer with Kon-Kave Bow



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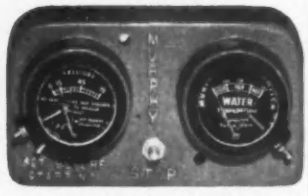

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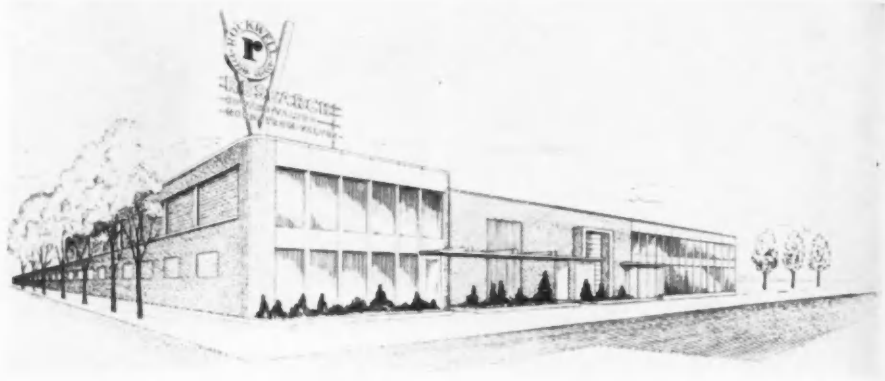

Edward Valves, Inc. Doubles Size of Laboratory

Edward Valves, Inc., subsidiary of Rockwell Manufacturing Company, has announced plans to double the size of its Research Laboratory at East Chicago, Ind. Shown here in an artist's drawing, the new steel frame, glass and glass brick addition, which will include a section devoted to development, assembly and final testing of nuclear power valves, will be completed in the spring.

Black, Sivalls & Bryson, Inc., announces the election of the following officers for BS&B International Corporation, Export division of Black, Sivalls & Bryson, Inc.: **Kenneth W. Lineberry**, president; **Abe Yeddis**, administrative vice president; **Hans Unger, Carlos Lavinas** and **M. G. Purpus**, vice presidents; **Frank Ruysser**, secretary; and **Keith Davis**, treasurer. As administrative vice president, Yeddis will direct operations of BS&B International Corporation, which has 37 sales representatives in 29 countries. Unger, who has been BS&B's export manager since 1951, will be responsible for all export sales of grain storage equipment, safety heads, and other items of the Steel Products division. Lavenas will be in charge of all oil field and automatic control equipment sales to export markets. Purpus, sales manager for the Steel Products division of Black, Sivalls & Bryson, Inc., will assist with special contracts for BS&B International Corporation. Headquarters are in Kansas City, Mo.

R. G. Chadderdon, newly-appointed export representative for **Houston Oil Field Material Company, Inc.**, will go into foreign fields periodically to gain information from companies operating the remote areas and to assist them with fishing or cutting, directional drilling or oil well surveying problems. Chadderdon has been with HOMCO nine years.

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Excessive sand and sediment holds back your oil. For fast, easy clean out with fewer round trips and less down-time, use world famous Miller Sand Pumps.

SAND PUMP SIZES
O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 In.
Lengths—20, 25, 30 ft.

Composite Catalog, Page 3369

Write for descriptive price list.

MILLER SAND PUMPS

Miller Sand Pump Co.
General Offices, Box 4516
Oklahoma City 9, Okla.

EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK CITY 20, N. Y.

DON'T FIGHT BOILER SCALE and CORROSION

Remove and Prevent with

SAND-BANUM
Pure Colloidal Concentrate
OUNCES ONLY ONCE A WEEK

For All Radiator Cooling Systems
Use SAND-BANUM SPECIAL in Handy Tablets

Also

SABCO
Rust Preventive Aluminum paint; 2 coats in one application.

RUSTEND
Clear Rust Arrestor—Rust Preventor

SABANOL
For clean and complete fuel oil burnability

Stocked by Leading Supply Houses
GULF COAST DISTRICT REPRESENTATIVES
Western Sand-Banum Company, 705 M & M Bldg., Houston 2, Texas
Colloid Products Co., 2825 Storey Lane, Dallas, Texas

AMERICAN SAND-BANUM CO.
ESTABLISHED 1926
MEADOW BROOK NATIONAL BANK BUILDING
FREEPORT, NEW YORK

USED EVERYWHERE! BY EVERYONE!
for lost circulation control
• HIGHER STRENGTH SEAL
• LASTS LONGER
• SEALS F-A-S-T-E-R
• LOWEST MAINTENANCE COST
• PERMITS MUD WEIGHT BUILD-UP WITHOUT FORMATION BREAKDOWN
and friction reduction
• LOWERS DRILL PIPE TORQUE
• DECREASES DRAG ON DRILL PIPE DURING TRIPS
• IMPROVES LUBRICATING PROPERTIES OF DRILLING FLUID
Available through your local mud and service companies
CHEROKEE LABORATORIES, Inc.
HOME OFFICE AND MANUFACTURING PLANT IN TULSA, OKLAHOMA
BRANCHES: MIDLAND, OKLAHOMA CITY, CORPUS CHRISTI, NEW ORLEANS, LAFAYETTE, LA., CASPER

Continental Supply Company announces the promotion of **Richard A. Cavanar** to Kansas-Oklahoma divisional sales manager. Cavanar, formerly divisional engineer will remain in the Tulsa headquarters of Continental's Kansas-Oklahoma division. He joined Continental as a student engineer for the Kansas district.

Lane-Wells has moved six district executives to new posts. **E. A. Radack**, formerly district superintendent, Southern Louisiana district, in New Iberia, moved to New Orleans on temporary assignment as assistant to the division manager. Replacing Radack, **A. L. Boyd** has transferred from Houston to New Iberia as district manager. **C. E. Shilcutt** moved from West Texas to Houston, where he will be district manager of the Houston district; and **J. W. Kiser** became district manager of the West Texas district, operating from Odessa. **R. G. Grant** moved from his New Orleans post as district sales engineer to Shreveport, where he became district manager of the Arklatex district, and **W. D. Long, Jr.**, formerly in the West Texas district, took over Grant's post as district sales engineer for the Southern Loujsiana district.

Bill J. Ellis

Russel A. Schlegel

Buck Jordan

Ed Moses

Otis Pressure Control, Inc., has announced the appointment of **Bill J. Ellis** as caliper engineer in the New Iberia, La., division. Ellis formerly was in the firm's Longview, Texas, division office and also has been stationed at Otis branches in Houston and Victoria. He began with the company in 1950 after working for Gulf Oil Corporation.

Russel A. Schlegel, now manager of industrial product sales for **Weston Electrical Instrument Corporation,** subsidiary of Daystrom, Incorporated, will assume complete responsibility for sale of Weston industrial instruments in domestic markets. Schlegel has had 19 years' experience in the instrument field, formerly handling the sale and application of industrial instruments and components to all major industries for the Brown Instrument division of Minneapolis-Honeywell Regulator Compaany.

Sivalls Tanks' promotion of **Buck Jordan** to the post of New Mexico branch manager and transfer of **Ed Moses** to Hobbs as sales and service representative have been reported. Jordan, who joined Sivalls Tanks, Inc., in 1952, later served as sales and service representative in Lea, Eddy and Chavez counties, N. M., and Culberson, Hudspeth and El Paso counties, Texas. Moses, who joined Sivalls in 1955, previously had worked as salesman in the Odessa district. His new territory includes the Texas counties of Gaines, Yoakum, Terry, Lynn, Cochran, Hockley, Lubbock, Crosby, Lamb and Hale.

Baash-Ross Tool Company, division of Joy Manufacturing Company, has announced the following transfers of sales personnel in the West Coast area: **Bill Grier,** formerly in Los Angeles City Sales, has been assigned to Long Beach district sales with headquarters in Long Beach; **Ed Carne,** formerly in Long Beach district sales, has been assigned to San Joaquin Valley sales with headquarters in Bakersfield; **Harold Adams,** formerly in San Joaquin, has been assigned to Coastal district sales with headquarters in Ventura; and **Bob Druecke,** formerly in Coastal district sales, has been assigned to Los Angeles.

with the Exclusive Speed Coupler

Strong, light-weight Tex-Tube with the exclusive Speed Coupler will solve your shot hole casing problems. Each length of Tex-Tube weighs only 20 pounds, making it easy to handle and speeding up operations. With the Speed Coupler, make-up is fast and no collars are required. Make-up completely engages the three threads in only two turns making a water tight connection strong enough to allow high pressure jetting. Field tests under every type of condition have proved Tex-Tube to be the best shot hole casing.

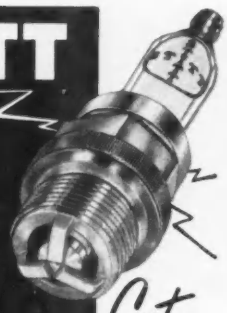
TEX-TUBE SUPPLY CO.

P. O. BOX 7705 HOUSTON, TEXAS UNDERWOOD 9-3411

Baton Rouge—5-1430
Corpus Christi—TUlip 2-8141
Lafayette, La.—CEnter 4-3876 (Gulf Coast Explosive Co., Inc.)
Mills, Wyo.—CAsper 2-7181 (TeTon Tool Co.)
Oklahoma City—JAckson 8-6740 (Deupree Dist. Co.)
Oklahoma City—JAckson 8-4886 (Grove Hardware Co.)

Dixie Dynamite Distributors, Inc.
Hattiesburg—JUniper 4-7256
Houma—8227
Jackson—6-6475
Lake Charles—HEmlock 3-3970
Shreveport—5-2502

STITT
NEW triple ignitor SPARK PLUGS



Cut "DOWN" TIME

"Down" time is costly and unproductive. Stitts run longer—cut down time for plug changes and mag checks. It's not the plug price, but the "change cost" that's important! Stitts cost a little more—save hundreds of dollars per engine per year. Factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

Free Write for Field Test Reports
$1 Gap Gauge

STITT Ignition Company
Columbus 1, Ohio

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BELL ENGINE SERVICE
BETHLEHEM SUPPLY CO.
CLARK BROS. CO.
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REAGAN EQUIPMENT CO.
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WAUKESHA-PACIFIC
WAUKESHA SALES & SERVICE Inc.
WORTHINGTON CORP.
MAGNETO IGNITION SERVICE R. ANGUS (ALBERTA) Ltd. CAN.
and Supply Stores Everywhere.

Proved by USE!

Works in seconds! **Loosens Rusted Bolts** *nuts, screws, "frozen" parts . . . . without breakage!*

LIQUID WRENCH

A powerful blend of quick-acting solvents that frees "frozen" parts without breakage. Safe for all metals and alloys.

Makes joints **LEAKPROOF!**

7 BASIC BLENDS

TiteSeal
GASKET & JOINT SEALING COMPOUND

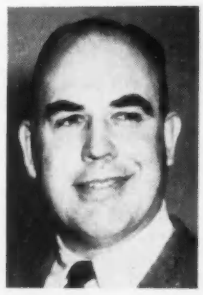
Makes all assemblies leakproof and pressure-tight. Easy to apply with brush-in-handle.

- NON-SOLVENT—WILL NOT HARDEN
- WILL NOT SHRINK, CRACK OR CRUMBLE
- HEATPROOF AND VIBRATION-PROOF

Get them at Industrial or Oil Field Supply Houses.

RADIATOR SPECIALTY CO.
Charlotte, North Carolina

Lloyd H. Lawrence



C. Eddie Trapp

Lloyd H. Lawrence has been advanced from assistant sales manager to sales manager of **Halliburton Oil Well Cementing Company** and **C. Eddie Trapp** from sales engineer to the new post of advertising manager. Lawrence began his Halliburton career in 1932, handling sales accounting. Trapp is a marketing and advertising specialist who joined Halliburton in 1934. In his new post he will supervise advertising, public relations and associated functions.

Myron C. Taylor, formerly chairman of the board and chief executive officer, has retired as a director of **United States Steel Corporation.** He served continuously for more than 30 years as a director and member of the Finance Committee of the corporation. He served as chairman of the Finance Committee from 1927 to 1934 and was chairman of the board and chief executive officer from 1932 to 1938. Following his retirement in 1938, Taylor distinguished himself in governmental service, holding the rank of ambassador from 1939 to 1953.

Thomas R. Hansen has been appointed assistant district manager of the Odessa district of Welex Jet Services, Inc. With the company three years, he began as a trainee and was sales engineer before his latest promotion. **James E. Brown,** who has been with Welex six years, is now assistant manager of the district office in Bartlesville. He has worked up through a succession of positions with the company, having started as a rigman. Prior to this appointment, he was district sales engineer at Bartlesville. **R. J. Johnston,** recently appointed sales engineer for the Wichita Falls district office of Welex, was promoted from sales engineer at the district office at Abilene.

Cable Engineering, Wichita Falls, Texas, announces the association of **Joel C. Kiester,** petroleum engineer. Kiester holds degrees from Oklahoma University in petroleum engineering and geological engineering, and has had three years' experience in well completion and well maintenance work.

Fairbanks, Morse & Company has announced appointment of **C. G. Gehringer** as manager of the Scale division. He succeeds **George C. Worthley** who retired December 31 after 41 years with the company. Gehringer joined the Cincinnati Branch sales organization in 1936 and was a field engineer for several years. He was named manager of the Louisville Branch in 1950 and, in 1952, transferred to the Chicago headquarters of the company as assistant manager of the Scale division.

We challenge you **to find better PROTECTIVE CLOTHING!**

illustrated above: ¾ length coat

Sawyer

for every industry where personnel protection and safety are vital, *only* Sawyer Neoprene Latex Clothing offers *all* these advantages:

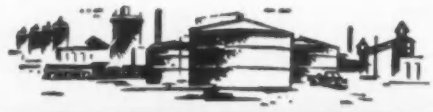
- **100% protection against oils, chemicals, alkalies, abrasion — and other hazards!**
- **"Exclusive Coating Process" . . . (for years and years of extra wear and durability) — *original* with Sawyer!**
- **guaranteed not to peel, blister or crack in ordinary usage!**
- **double interlocked sewn seams that *can't* come apart!**
- **solid brass or non-conductive fastenings that *can't* rip off or corrode!**
- **designed for roomy, action-free comfort!**

Sawyer clothing also Rubberized or Oiled. Full range of jackets, pants, coats, hats, aprons for *more* efficiency, *more* economy, *more* protection on *every* job!

Make us prove it!

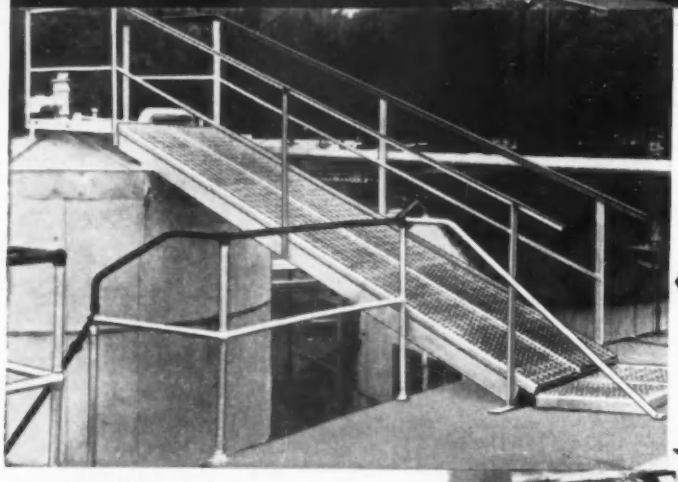
Send for complete details and price list.

The H. M. Sawyer & Son Company
A Division of Sawyer-Tower, Inc.
specialists in Protective Clothing for more than a century
7 Thorndike St., Cambridge 41, Mass.



Use SAFETY
GRIP-STRUT
grating

Wherever a safe footing is required

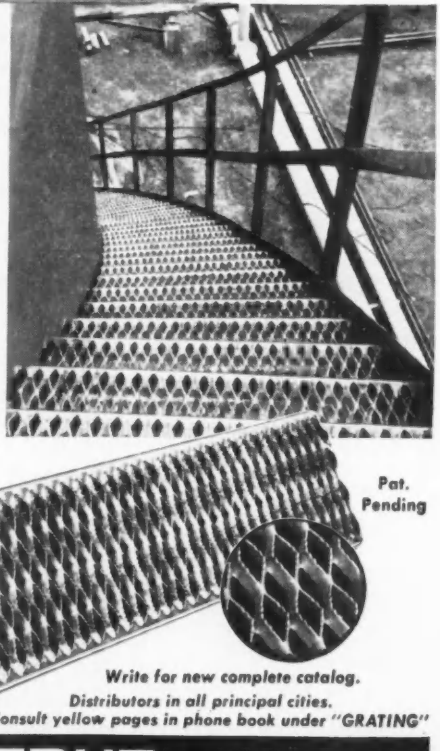


Grip-Strut circular stairway on Shell Oil tank in Portland, Ore.

See how Shell Oil uses Grip-Strut for a safe ramp between tanks.

View looking down circular stairway on Shell Oil tank shown above.

SAFETY GRIP-STRUT is the new basic material, all in one piece (including channels), not welded, riveted or expanded in steel or aluminum, in standard sizes and gauges. Safety GRIP-STRUT presents an open space, in a diamond pattern, in excess of 55% of the area for ready access of light and air and gives a positive NON-SKID footing in all directions. Ideal for work platforms, stair and ladder steps, flooring, balconies, catwalks, machinery guards, fire escapes and for original equipment safety treads.



Important Safety Features

★ Fire proof
★ Slip proof
★ Maximum strength
★ Minimum weight
★ Easy to stand on
★ Cool in summer—warm in winter

Pat. Pending

Write for new complete catalog.
Distributors in all principal cities.
Consult yellow pages in phone book under "GRATING"

GRIP-STRUT division
THE GLOBE COMPANY • *Manufacturers since 1914*
4008 S. PRINCETON AVE. • CHICAGO 9, ILL.

Pierre Maugis

M. Mark Watkins

Rogers Geophysical Company announces the appointment of **Pierre Maugis** as director of Exploration Geophysique Rogers with offices in Paris, France. The company is an affiliate of Rogers Geophysical Company of Houston. Maugis, who will serve as director of this company in France and the French Union, has held various engineering and executive positions with oil companies and petroleum societies.

M. Mark Watkins, recently elected a director of **Walworth Company**, is executive vice president and a director of Conoflow Corporation which was acquired recently by Walworth. Watkins joined Conoflow in 1943 as vice president, treasurer and director. He also is vice president and a director of Remington Corporation.

Joy Manufacturing Company has announced the retirement of **J. D. A. Morrow** as president and his election as chairman of the board. To succeed him, the directors advanced **John Lawrence** to president and chief executive officer; **W. L. Wearly** to executive vice president; and **H. C. Nyquist** to vice president, general sales. Morrow has served as president of Joy since 1940. Lawrence went to Joy in 1951 from SKF Industries, Inc., where he was manufacturing and engineering vice president. He began with Joy as vice president, manufacturing, and for the past year and a half has been executive vice president. Wearly began with Joy in 1937 and, after working in production, engineering, and service capacities, became vice president in charge of coal machinery sales. For the last three years he has been vice president, general sales. Nyquist, formerly with Tennessee Coal, Iron and Railroad Company, served as district sales manager in the anthracite and West Virginia areas for Joy, then was promoted to vice president, coal machinery sales.

Dana T. Hughes has been appointed director of public relations, reporting to the office of **ALCO Products, Inc.'s** president, Perry T. Egbert. Now manager of ALCO's news bureau is **Roger C. Witherell**, who recently joined the company from the editorial staff of the Albany Knickerbocker News. Both Hughes and Witherell will be located at Schenectady. In his new capacity, Hughes will be responsible for all public relations activities on a company-wide basis. He also will have over-all responsibility for operation of the news bureau and will handle various special events concerning new products, facilities and processes. Hughes joined the ALCO public relations department in 1952 and was named director of information in 1954. Witherell formerly was with the Knickerbocker News and the Albany bureau staff of The Associated Press.

(For more data on advertised products, use Readers' Service blue cards, last page this issue.)

Jack Grundy

John P. Mansfield

Jack Grundy, recently named factory manager for **Reed Roller Bit Company,** first worked for the company as a draftsman. He has since held such posts as purchasing agent, production manager, materials manager and assistant factory manager. Announcements also have been made of the appointments of **C. L. McKee** as production manager and **R. G. Stockton** as purchasing agent. McKee has been a special salesman, supervisor of material control, supervisor of raw material and assistant production manager since he first joined Reed. Stockton, who was in the Raw Materials and Purchasing departments since joining the company, was assistant production manager before his new assignment. All three men have been with Reed since 1937.

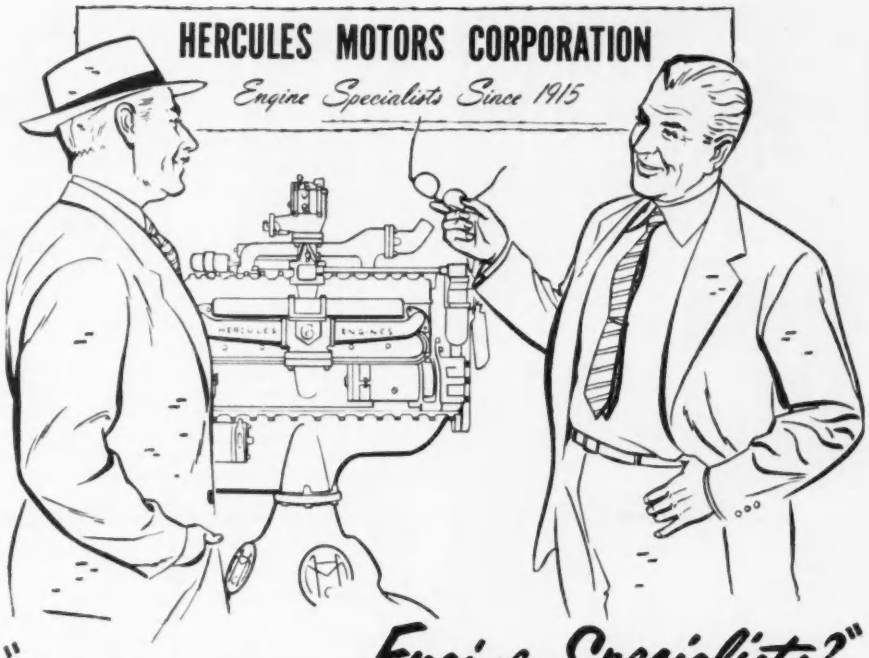
John P. Mansfield has been promoted by **The Western Company** to assistant sales manager in charge of staff operations. He moved up from assistant to the sales manager, a position he had held since 1953. Mansfield, who started with the company in 1952, served as special agent with the Federal Bureau of Investigation from 1941 to 1952.

C. M. Moore, Jr., formerly in charge of Canadian operations for **Geophysical Service Inc.,** has been elected vice president. He will maintain offices in Dallas, and will direct petroleum exploration activities in the Eastern Hemisphere. As a result of Moore's appointment, expanded duties were announced for Vice President **R. C. Dunlap, Jr.,** who, in addition to his present duties as director of U. S. operations, will assume responsibility for Canadian operations. Dunlap will remain in Dallas. Both Dunlap and Moore have been with GSI for more than 21 years. **R. H. Wright,** manager of GSI's Southern division office at Houston, has been appointed area manager for Canada, with offices at Calgary, Alberta. The division post at Houston will be filled by **T. P. Ellsworth,** who has been serving as manager of the West Coast division. Ellsworth's position will be taken by **J. Frank Fuller,** formerly a GSI supervisor in the West Coast division. His offices will be at Bakersfield, Calif.

Lee J. Hoffman, manager of the Franklin Plant of the **Chicago Pneumatic Tool Company,** has retired after 46 years of service in the company's Air Compressor and Diesel Engine division. He joined the company as an apprentice draftsman in 1909; eight years later he was appointed chief engineer and served in that capacity until his appointment as plant manager in 1930. Hoffman, who was elected to the company's board of directors in 1948, will continue in his capacity as a director. He will be succeeded as plant manager by **H. E. Moore,** with the company since 1919.

HERCULES MOTORS CORPORATION

Engine Specialists Since 1915



"What do we mean . . . *Engine Specialists?*"

Briefly, it means that Hercules manufactures engines to meet the customer's requirements. These engines are produced by modern methods and each engine is tailored to fit the equipment which it will power.

The wide selection of engine sizes in the Hercules line, plus the flexibility of our production facilities enable us to specialize in building engines to meet the customers needs. We have over 90 different basic engine models, ranging from 3 to 500 H.P., available for operation on gasoline, diesel fuel, L.P.G., natural gas and kerosene.

Further, it is our policy to work with customers and to help them select the type of engine best suited for their equipment. We do more than merely suggest the use of a standard type engine. Hercules engineers work with the product engineers to select an engine with accessories and other engine components modified or positioned to fit the requirements of the end product. After these engineering problems are solved and the test engine has proved itself, our production of these engines is scheduled to meet your delivery requirements.

Whether your engine requirements are for 1 or 1001, specify Hercules Engines, the product of Engine Specialists Since 1915.

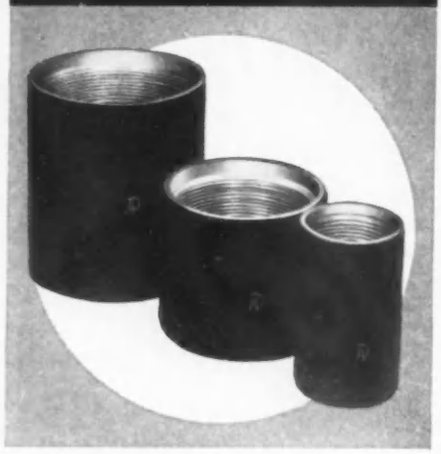
Engine Manufacturing Specialists Since 1915

HERCULES ENGINES

HERCULES MOTORS CORP., 117 Eleventh St.,S.E., Canton, O.

(For more data on advertised products, use Readers' Service blue cards, last page this issue.)

ALL COUPLINGS
for the oil industry



A.P.I. LINE COUPLINGS

Sizes ⅛" through 12", 14" and 16" O.D. Black and Galvanized. Recessed, Taper Tapped ¾" per foot.

A.P.I. CASING COUPLINGS

Short and Long, sizes 4½" through 13⅜". All threads 8 round, ¾" taper per foot. Combination casing couplings also available.

A.P.I. TUBING COUPLINGS

Non-Upset sizes 1.900" through 4½". Upset sizes 1.660" through 4".

OTHER OIL INDUSTRY ITEMS

Couplings-Standard Merchant, 3000 and 6000 lb. Hydraulic and all other types of special couplings.
Hex Bushings, Square Head and Hex Head Solid Plugs, Nipples, Unions, Steel Socket Weld Couplings and Caps.

CAP CAPITOL
MFG. & SUPPLY CO.
COLUMBUS, OHIO

COUPLINGS — NIPPLES — UNIONS — RADIANT HEAT FITTINGS — FURNACE COILS — WELL SUPPLIES — STEEL PIPE FITTINGS

A. Clark Daugherty

Emil R. Albert

A. Clark Daugherty, former market research manager of **Rockwell Manufacturing Company**, has been named assistant to the president. Market Research, Public Relations and Stockholder Information departments will continue to report to Daugherty, who has also been assigned additional management functions. Daugherty joined Rockwell in 1946.

Emil R. Albert, Jr., named president and general manager of **Rubarite, Inc.**, of Chicago, succeeds **Harold B. Pullar** who remains with the company as an officer and director. Rubarite, owned by National Lead Company, the Goodyear Tire & Rubber Company and Bird & Sons, Inc., produces a rubber additive used in asphalt and tar. Company headquarters in Chicago will be moved to Tulsa. Albert joined Rubarite after more than 20 years of experience in the oil well drilling field with Gulf Oil Company, Baroid Sales division of National Lead Company and Mud Products, Inc.

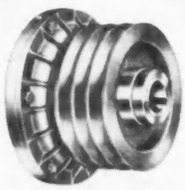
Wagner Electric Corporation recently announced the appointment of **John K. Oliver** as manager of the Portland, Ore., electrical division branch office. Joining Wagner as a student engineer in 1948, Oliver was sales engineer in the Seattle and Portland branch offices before his new appointment.

H. J. Schlarb has joined **Emsco Manufacturing Company** as sales manager of the Swivel Joint division. A recognized authority on swivel joints and fittings, he was assistant sales manager, Southern California district manager and special representative of Chiksan during the past 11 years.

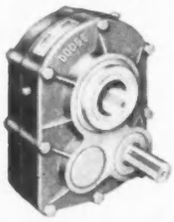
L. J. (Lew) Morris succeeds **W. C. Robinson** as assistant district manager for **Tube Turns** at Pittsburgh. Robinson recently was made an assistant sales manager engaged in sales promotional programs in the company's Eastern division. Morris was process equipment buyer for the Fraser-Brace Engineering Company before joining one of Tube Turns' affiliated companies in 1943. He became a member of the Pittsburgh sales staff in 1949. **T. T. (Jock) Thompson**, formerly representative of the Watson-Stillman Fittings division of H. K. Porter Company, has been added to Tube Turns' sales staff at Pittsburgh.

Republic Steel Corporation recently announced that **J. French Robinson**, recently retired president of Consolidated Natural Gas Company and chairman of East Ohio Gas Company, has joined the staff of the steel company in an advisory capacity. Robinson retired from his position with Consolidated in November, 1955, and joined Republic the first of the year.

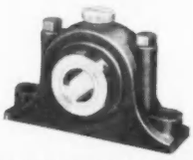
DODGE PRODUCTS
You Should Know-



FLEXIDYNE
DRIVES & COUPLINGS



TORQUE-ARM
SPEED REDUCERS



DODGE-TIMKEN
PILLOW BLOCKS

Dodge Bulletins you should have-

- ☒ Flexidyne Dry Fluid Drives and Couplings. Complete story and selection data. Bulletin A-640-A.
- ☒ Torque-Arm Speed Reducers. Technical data and selection methods on all 14 sizes, 1 to 60 hp. Bulletin A-637.
- ☒ Rolling Bearings. Load ratings, dimensions and other data on Dodge-Timken and SC and SCM Ball Bearings. Bulletin A-638.

Write for your copies.

DODGE
of Mishawaka, Ind.
DODGE MANUFACTURING CORPORATION
6500 Union Street • Mishawaka, Indiana

David D. Gordon

W. M. Steed

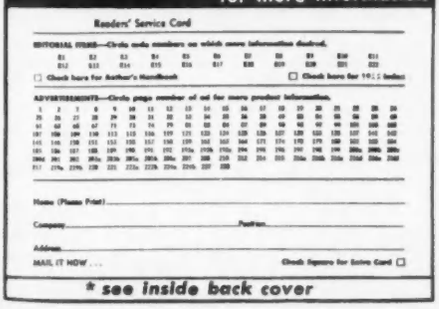
David D. Gordon's appointment as sales manager for the Los Angeles district of Fulton Sylphon division, **Robertshaw-Fulton Controls Company,** recently was announced. **W. J. Hajek,** former manager of the Los Angeles office, has been transferred to the Chicago office. Gordon's territory covers California, Washington and Oregon. He has been with the Robertshaw-Fulton organization 13 years, serving as coordinator of research and supervisor of original equipment division for Fulton Sylphon.

W. M. Steed, newly-appointed regional manager, Southwest region, **Cummins Engine Company, Inc.,** joined the diesel manufacturer as sales engineer in 1951. Prior to his recent appointment he was regional representative, Central region, with offices in Chicago. In Los Angeles his new headquarters are in the Equitable Life building.

Richard H. Marsh has been appointed Worksaver and Warehouser sales manager by **The Yale & Towne Manufacturing Company.** He was promoted from assistant sales manager of the two industrial lines. Marsh joined the Yale sales organization in 1948, working in various capacities in several of the company's industrial truck sales departments before being named to the assistantship. **Fred E. Rau,** hoist equipment district sales manager in Cleveland for Yale & Towne, has been named to the newly-created post of assistant hoist sales manager. He joined the sales staff of Yale in 1948 and was appointed to the Cleveland territory in 1952.

G. R. Cuthbertson has been promoted to assistant general manager of the Tire division, **United States Rubber Company.** With U. S. Rubber since 1936, he has been production manager for the divisison more than a year. **R. E. Behrman,** who had been assistant production manager, will succeed Cuthbertson as production manager. Behrman started with the company in 1922 as an office boy at the Indianapolis plant.

use these
READERS' SERVICE CARDS*
for more information



* see inside back cover

Joseph E. Cox's election as vice president of **Thermoid Company** and general manager of Essex Rubber, a Thermoid division, recently was announced. A veteran of 32 years in the rubber industry, Cox has been with Essex Rubber since 1946. Prior to that he was with Goodyear Tire & Rubber Company.

Stanley L. Hake has been appointed supervisor of the Midland district for **National Geophysical Company, Inc.** He will headquarter in Midland. Prior to joining the company, Hake served five years as supervisor in the Midland district for a contract exploration company, and eight years with The Texas Company.

Cecil H. Green's election as chairman of the board and the election of **Fred J. Agnich** as president of **Geophysical Service Inc.** has been announced. Green was elected to the position formerly held by **J. Erik Jonsson,** who will devote full time to duties as president of Texas Instruments Incorporated, parent company of the TI-GSI organization. Agnich becomes principal executive officer of the geophysical exploration subsidiaries of Texas Instruments. Also a director of TI, he formerly was executive vice president of GSI, which he joined in 1937 as a recording helper. Green joined Geophysical Service Inc. shortly after its organization in 1930. He has served as party chief and field supervisor in both foreign and domestic operations of the firm, being named president in 1950.

157 OIL & GAS STOCKS
Rated BUY, HOLD or SWITCH
104 United States Issues and 53 Canadian Issues

Oil and natural gas stocks are, we believe, entering a period of selectivity. There are developments indicating sharp price advances in certain issues, a sidewise trend in others, and declining prices in still others. By holding and buying the right stocks you can *save money* and make *bigger profits.*

We have just completed a thorough check of all our Ratings on 157 oil and natural gas stocks—104 United States issues and 53 Canadian issues.

Of the 157 issues, we rate 66 as fairly priced. These are marked "HOLD" for satisfactory appreciation potentials. There are, however, 50 issues which we believe have far over-shot all reasonable price targets. These are rated "SWITCH" *to save you losses over the next 6 months.*

There are 41 stocks which we believe can be bought for profit. Of these 41 stocks rated "BUY," *15 look especially attractive for purchase* within the next 30 days. Also, there are 4 issues, (2 around $10 and 2 under $5), all off-the-beaten-path, which we believe possess *unusual profit possibilities.*

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YOU WILL ALSO RECEIVE

Our 2 Special Reports entitled "15 OILS TO BUY FOR WIDE 1956 PRICE GAINS" and "FOR EXTRA BIG PROFITS—4 OFF-THE-BEATEN-PATH OILS (2 AROUND $10 AND 2 UNDER $5)."

Of the 15 stocks rated "BUY" one is very special. Company may now be on the verge of duplicating a previous similar discovery which sent the stock zooming 300% in 2 years! *This is an outstanding opportunity.*

One of the "off-the-beaten-path" oils is a big "land-play" situation with, we believe, tremendous upside possibilities at very little risk. *Similar stiuations in the past have resulted in large and fast capital gains.*

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Both of these Bulletins are recognized throughout the world as authorities on North American oil and natural gas stocks.

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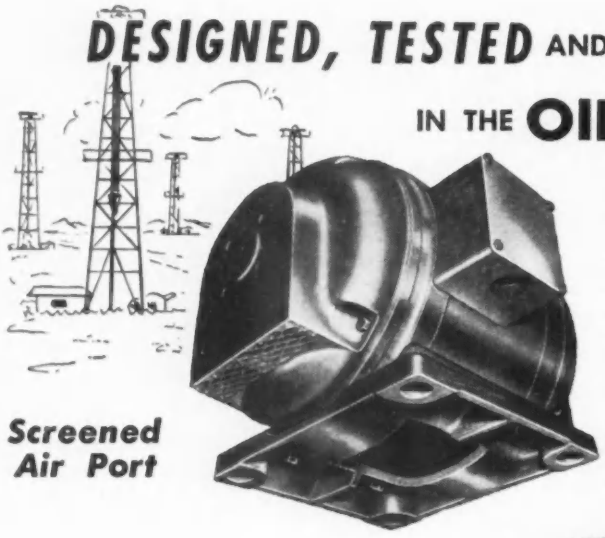

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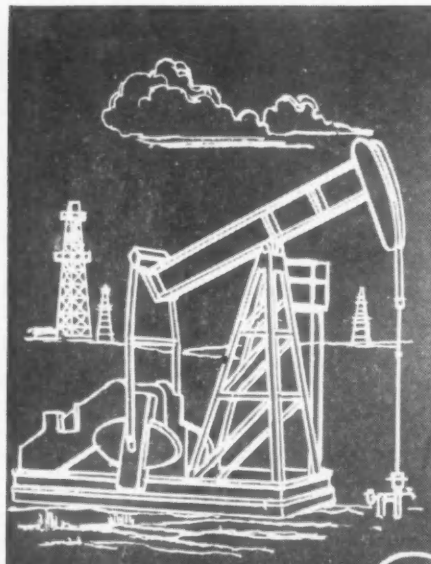

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The Casper, Wyo., Petroleum Club is the first to own an oil portrait of Joe Roughneck. The big painting was presented by L. D. (Red) Webster, vice president, Lone Star Steel Company, left, and was accepted for the club by Ray A. Sing, president, right. R. L. Gibbins, administrative assistant in Lone Star's Sales department, presented individual Roughneck Club plaques to 30 charter members of the newly-organized Casper chapter. Lone Star Steel is sponsor of the Roughneck's club.

Casper Petroleum Club Given Portrait of Joe Roughneck

With 30 charter members being named by an anonymous committee, the Roughneck's Club of Casper, Wyo., was organized February 14, 1956. Feature of the meeting was presentation of a large oil portrait of Lone Star Steel Company's "Joe Roughneck" to the Casper petroleum club.

Charter members are H. A. True, Jr., M. E. Peden, Sam Rogers, W. J. Williams, A. O. Bullock, Guy Keith, D. E. Bland, Henry T. Gist, Tom Grannell, R. E. Tinsley, John J. Oldham, G. E. Stevens, M. M. Brown and Sam T. Dyer.

Also, Gabe McCall, W. G. Tschudin, Fred Goodstein, J. D. Sprecher, J. M. McIntire, M. J. Boyce, Tom LaMor, Joe Fusselman, J. D. Simmons, H. B. Gernert, G. A. Isaacks, John J. Sullivan, John Roden, C. J. Matthews, Ray A. Sing and R. M. Olds.

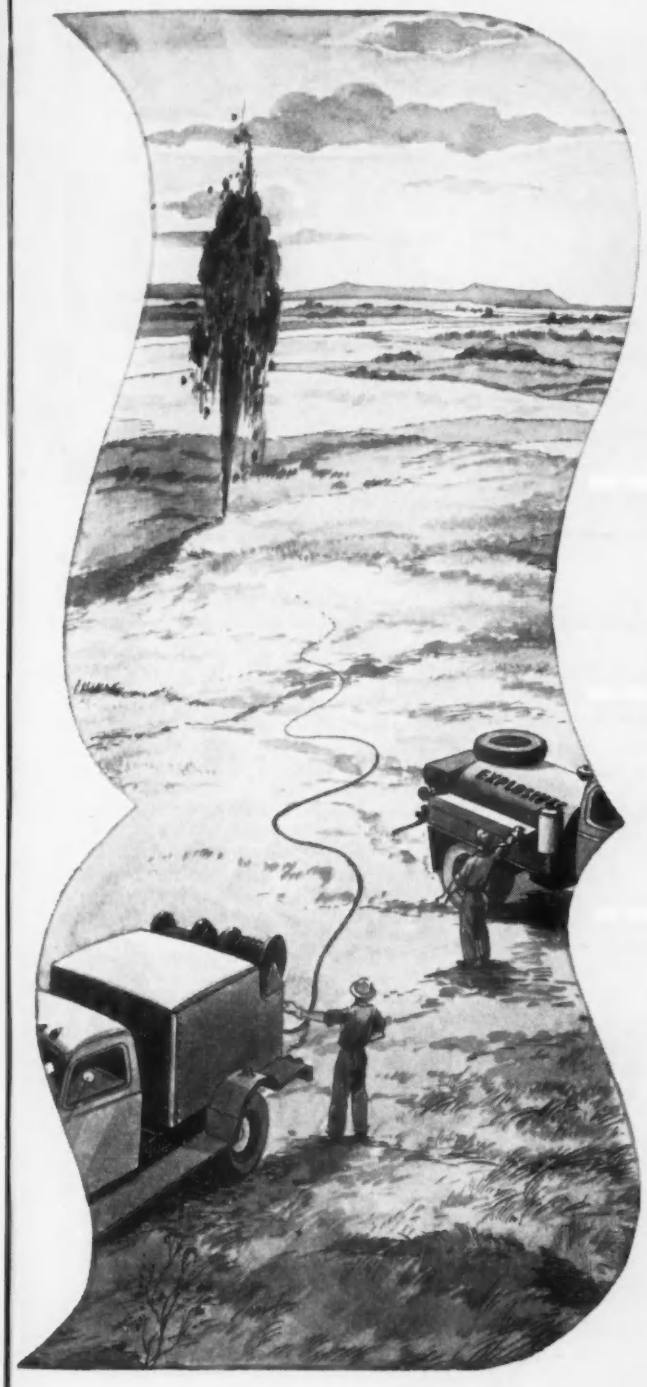
Purpose of the Roughneck Club is to recognize the pioneers of the U. S. petroleum industry. Individual plaques presented to the 30 charter members denote that the recipient has rendered rough and rugged service in the field to achieve a place of honor in the oil industry.

Elgen Corporation Begins Construction of Dallas Office

The Elgen Corporation, electrical well logging service organization, recently began construction of its own home office building on a five-acre tract in the Bluff View Industrial district of Dallas. Completion of the modern brick and glass building is scheduled for July 1.

The new quarters will house administrative offices, research laboratories, manufacturing area and machine shop. Value of land, building and equipment will be in excess of $250,000. The coporation, since its founding in 1953, has opened division offices in Wichita Falls, Graham, Abilene, Ballinger, Gainesville, Shawnee, Duncan and Ponca City.

Officials of the Elgen Corporation include Kirby C. Gee, president; Paul L. Elvington, vice president; and Floyd A. Wooldridge, secretary and treasurer. John E. Kilgore is chairman of the board.



Men and Equipment Dedicated to the Job

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Our men are thoroughly trained and widely experienced. In addition, they are loyal, conscientious and dedicated to their work.

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The House of Courteous Service

Many special features were designed into Eidal Manufacturing Company's giant bogie, manufactured for use on the world's largest mobile rig. The bogie is over 12 feet wide and 40 feet long.

Eidal Designed Giant Bogie For World's Largest Mobile Rig

Eidel Manufacturing Company of Albuquerque, N. M., has delivered the largest tandem axle trailer bogie ever designed and manufactured for use on the largest mobile rig in the world. Some of the outstanding features of the Eidel bogie are:

1. First dual mounting of 18:00 x 24 tires on steel disc wheels. Special wheels, designed and manufactured by Eidal, were required as no standard wheel is available for dual mounting of this size tire.

2. Special axles made of 5½-inch solid bar heat treated stock. Bogies have integral spindles and standard brakes with interchangeable parts.

3. Special springs, leaf type, each made up of 17 leaves of ¾-inch thick by five-inch wide spring steel. Length of spring is six feet. Weight of each spring is almost 1000 pounds.

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WARN MFG. CO., Riverton Box 6064-WO4, Seattle 88, Washington

is 154 inches, 12 feet-10 inches; over-all length is 124⅜ inches, 10 feet-4⅜ inches. Height of tire unloaded is 51⅛ inches; wheel base of bogie is 63¼ inches; and track is 112¼ inches. Design load is 110,000 pounds.

Bermann Is Sales Manager Of M-H-F Industrial Division

A new industrial division has been established by Massey-Harris-Ferguson, Inc. to market a full line of light and medium-duty industrial wheel tractors and allied equipment. B. R. Bermann, formerly general service manager of the Ferguson division, has been named sales manager.

Dealers will handle the entire line, stock repair parts and provide complete service facilities. The line has been designed to provide a package of equipment involving tractors of the light and medium-duty size and accompanying work tools.

Hardy-Griffin Engineering Begins Operation in Houston

The Hardy-Griffin Engineering Corporation, the firm offering first introduction of a high pressure sealed joint to withstand high temperature for oil and gas wells, began operation in late February in Houston. After a change in plans for construction of an office and plant building, the firm began processing tubing with its HGT sealed joint in a plant and office building at 12920 South Main Street. Quarters allow for immediate installation of equipment with storage ground and room for expansion.

The company is headed by John M. Hardy, president, and W. H. (Bill) Griffin, executive vice president.

Schlumberger Station Opened in Colorado

A new field location has been opened recently by Schlumberger Well Surveying Corporation at Cortez, Colo. G. F. Chambliss will be in charge of the new station.

Clark Equipment Forms International Subsidiary

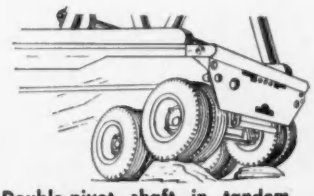
Clark Equipment Company announces formation of a new subsidiary to consolidate export functions of the firm's operating divisions throughout the world.

The new corporation to be known as Clark Equipment International, C. A., is being organized under the laws of Venezuela. Domestic branch offices will be established at Battle Creek, Mich., and Benton Harbor, Mich. Authorized capitalization will be $250,000 and stockholders will be Clark Equipment, with 99 per cent of the outstanding shares, and Canadian Clark, Ltd. owning the remainder. The latter is a wholly-owned subsidiary organized by Clark Equipment Company to operate in Canada.

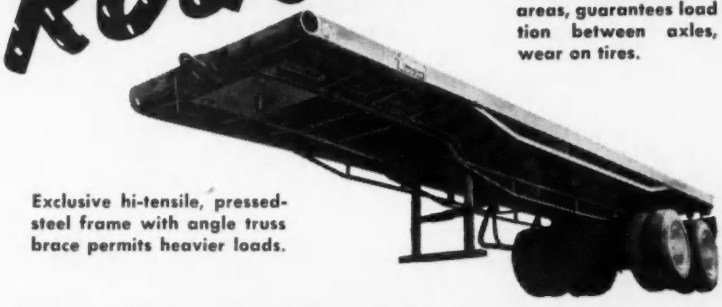
In addition to centralizing present export operations, the new subsidiary will promote new markets for materials handling industrial trucks, construction equipment and heavy automotive components manufactured by Clark. It also will have supervision over Clark licensees and companies abroad in which Clark has an equity interest. Distributor sales abroad also will be handled through the subsidiary.

The company will be staffed initially by personnel from the export departments of the company's operating divisions.

SMOOTH RIDES IN THE ROUGH



Double-pivot shaft in tandem keeps load in balance in rough areas, guarantees load equalization between axles, reduces wear on tires.



Exclusive hi-tensile, pressed-steel frame with angle truss brace permits heavier loads.

Look to Loadcraft for dependability in meeting your oil field transportation requirements. Since the first pole trailer was built 40 years ago by Fred Spencer, trailer manufacturers have attempted to duplicate Spencer quality. Pulls easier because of Spencer True-Beam Axle with machined-in camber, for correct toe-in, maximum tire life. Optional rolling tail pipe for rear loading has self-aligning roller bearings in each end. Find out for yourself that a Spencer Trailer is a quality trailer.

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Choose from a complete line of Pole and Pipe-line Trailers, as well as tandem or single-axle, semi-floats, or low-beds.

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Just Install As You Would Regular Slips
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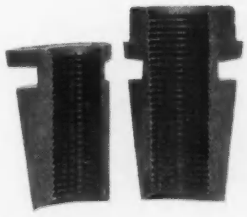

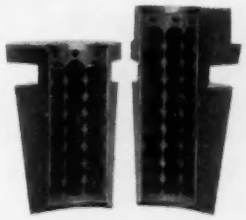

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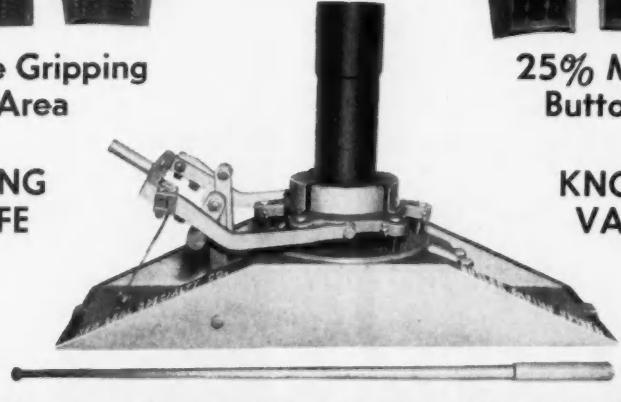

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(For more data on advertised products, use Readers' Service blue cards, last page this issue.)

Oil Base, Inc. Announces U. S., Foreign Distributors

Lamb Transportation Company, Long Beach, Calif., has been named distributor of Oil Base, Inc.'s No-Glo oil and No-Glo non-fluorescent thread lubricant for all of California. Terminal Petroleum Company, Harvey, La., has been named distributor in the New Orleans delta area, including offshore operations; Southwest Texas Oil Sales, Sinton, will service south and southwest Texas; and M & H Distributors, McAllen, Texas, has been named to serve the Rio Grande Valley.

In Venezuela, Oil Base has appointed Baritina de Venezuela, S. A., Caracas, distributor of Black Magic drilling muds and other OBI products. George Crocker and John Simons, both OBI trained servicing engineers, are available to the entire Venezuelan area. A Z Export, S. A., in Bogota, Colombia, will serve all of Colombia, with M. R. Vollmer as representative.

In Western Canada and serving the provinces from stocks in Red Deer, Alberta, will be Pacific Western Mud Service, Ltd. of Calgary, Alberta. Clint Buffington, another OBI trained representative, is in charge of operations.

Jack Long, assistant general manager of Oil Base, left recently for an extended trip through Colombia and Venezuela to visit the company's two new distributors. Purpose of the trip is to plan expansion of OBI sales in the South American areas.

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Slip-on fittings eliminate flanging, threading, welding; saving hours of installation time. No special tools or skill required to install, and all Slip-on's are reclaimable. Every joint is a union, making it easy and inexpensive to take a line apart. They permit misalignment up to 11°, absorbing shock, ground motion, expansion and contraction. They are recommended for permanent installations. Write for catalog page 11-01.

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Steve Drane — Houston, Texas
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Harry Higginbotham — Tulsa, Okla.
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*Reg. T.M.

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Safety Patent Contributed To Oil Industry by PGAC

Perforating Guns Atlas Corporation has announced outright contribution by the company of an important safety patent to all companies licensed to operate under the jet process in perforating oil and gas wells. The company's new jet gun blasting cap assembly and circuit, which does away with the hazards of the conventional blasting cap, is now available to the industry without payment of royalty.

Gardner-Denver Company Expands Oil Field Facilities

Gardner-Denver Company, manfacturer of pumps and compressors for the petroleum industry, recently expanded its facilities for serving the industry, and increased personnel in its Oil Field division. The enlarged operations are headed by O. C. (Butch) Knapheide, now manager of the Oil Field division. He joined the sales department in 1935, and was named sales manager of Industrial and Oil Field divisions in 1953.

An extensive, new fabricating and assembly plant in Dallas also is in full operation where packaged pump and compressor units are assembled, according to customer specifications.

Cook Buys Firm; Organizes Oil Well Testing Service

R. M. Cook has purchased patents and physical assets of the Acme Tool and Testing Company of Long Beach, Calif., and now is operating an oil well testing service under the name of Cook Testing Company. The Cook formation tester, the original successful controlled opening tester, was invented and placed on the market by Boyd McKinley of Acme Tool, who will remain with Cook Testing Company.

Cook, who has had many years of sales and executive experience with Pacific Cementing, Byron Jackson, International Cementers, McCullough Tool Company, Security Engineering Company and Great Lakes Carbon, has organized the new firm to provide a complete formation testing service, including bullet and jet perforating, in conjunction with testing. "Hi" Whitney, formerly of Security Engineering Company, and John Dickmann, formerly chief engineer of Baash-Ross, now are with Cook Testing.

Gas Lift Equipment Firm Announces Name Change

Harold Brown, president, has announced that the name of McMurry-Brown, Inc. has been changed to Harold Brown Company. The Houston firm manufactures a line of gas lift equipment.

The change in name is one part of a general expansion program; other phases include removal of the main offices to new quarters and addition of new products to the line of equipment offered.

American Iron and Machine Works Names South American Distributor

Norman Yett and Associates has been appointed South American sales representative for American Iron and Machine Works Company, Inc., of Oklahoma City. From headquarters in Maracaibo, the firm will sell and service American Iron products in Venezuela and other oil producing sections of South America.

John Kinkaid

Joe Jennings

Grant Oil Tool Company Announces Expanded Service

Grant Oil Tool Company has announced immediate expansion of service coverage in the Gulf Coast area and in California.

Titus Carter

On the Gulf Coast, the company has opened service facilities and a warehouse at Harvey, La. John Kinkaid has been transferred from Lafayette to Harvey, where he will manage the new facilities. Kinkaid started his oil industry career with Grant as a field salesman, after having worked for a major bit manufacturer. In 1955 he was promoted to office manager of the Lafayette branch of Grant where he served until his present transfer and promotion to assistant district manager of the Louisiana branch.

New field representative for Grant at Lafayette is Joe Jennings, transferred from the Los Angeles basin branch. Jennings started in the industry in 1932 in the Kettleman Hills area. After a period with a bit manufacturer and after working in Louisiana and Texas, he joined Grant Oil Tool Company.

Titus (Nick) Carter joined the Grant sales organization as field salesman in the Los Angeles basin area. He worked for a California oil tool manufacturer 11 years prior to his appointment as salesman for Grant in the Los Angeles area. In his new capacity he will work out of the Compton, Calif., branch.

Mid-Continent Supply Announces Opening of Store at Harvey, La.

Mid-Continent Supply Company recently announced opening of the organization's newest field store at Harvey, La. Mid-Continent maintains Louisiana Gulf Coast stores and locations at Harvey, Houma, Lake Charles, New Orleans and New Iberia. New Orleans is district headquarters for the organization's Louisiana Gulf Coast area.

Manager of the new store is G. E. Belanger, formerly with Mid-Continent at Houma. Field salesmen are B. H. LeNorman and E. R. McMullan. Storemen include M. L. Black, H. E. Carney, J. E. Moon and H. L. Knieff. New Orleans district manager R. S. Weilman supervises the operation.

The store is of all-steel construction and has been placed near the Harvey Industrial Canal for prompt transfer of supplies and materials to crew boats and tugs for delivery to offshore locations.

Minneapolis-Honeywell Adds 21 to Sales Posts

Twenty-one sales engineers have been added to the field sales force of Minneapolis-Honeywell Regulator Company's Industrial division. They were assigned to 19 branch offices located in 18 U. S. cities and one Canadian city. The new sales engineers are all graduates of the division's training school's twentieth anniversary class.

The appointees include: William Bater and Robert W. O'Reilly, Philadelphia. David B. Beasley, Toronto; Walter E. Biewer and Robert E. Day, Los Angeles; Robert J. Byers, Milwaukee; A. P. Ciprari, International division, New York; Alan L. Colter, Buffalo; John L. Dyer, Cincinnati; Merton H. Fischer, International division, Minneapolis; Michael N. Francher, Syracuse, and Eugene D. Haugen, Seattle.

Also, Charles C. Hulsey, Columbia; Charles B. MacRae, Houston; Robert J. Owen, Cleveland; John B. Prouty, Columbus; Harvey F. Renee, Indianapolis; Bertram R. Robinson, Union; Russell W. Skinner, Pittsburgh; Jack D. Stickley, Oklahoma City, and Richard E. Swenson, Twin City.

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Service parts readily available in all oil fields

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(For more data on advertised products, use Readers' Service blue cards, last page this issue.)

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RATES: Regular Classified (undisplayed) set in this size type: 12 cents per word. Minimum charge, $3. Blind box address in our care counts six words. Replies forwarded without charge. **Situation wanted ads,** 6 cents per word. **Display ads,** set in suitably larger type with ruled border, $12 per column inch; situation wanted display ads, $6 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All classified ads payable in advance. COPY DEADLINE:** 17th of month preceding date of issue. Send copy and checks to: **Trading Post Section, World Oil. P. O. Box 2608, Houston, Texas.**

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■ Professor of Petroleum Engineering to be responsible for undergraduate curriculum and graduate courses. M.S. or Ph.D. Interest in research desired and full cooperation of University assured. Rank and salary dependent upon education and experience. Box 81-W, WORLD OIL, Houston, Texas.

Position of well-rounded seismologist with French oil company operating both in France and Madagascar. Man must have several years' experience. Box 92-W, WORLD OIL, Houston, Texas.

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Position of petroleum geologist with French oil company operating both in France and Madagascar. Man must have several years' experience. Box 94-W, WORLD OIL, Houston, Texas.

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Thirty-five; fifteen years' experience in various phases of oil production in U. S., Canada, South America. Currently senior geologist with major company in South America. Seeking connection with organization having active development program. Prefer foreign, but will consider domestic assignment. Geologist or Petroleum Engineer. Box 84-W, WORLD OIL, Houston, Texas.

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GEOPHYSICIST—With 8 years domestic and foreign experience in all phases of reflection Seismic work desires position as supervisor and/or reinterpretational work. Interpretational experience with tensional, compressional, and stratigraphic types of structures. Bachelors degree plus one year graduate work in Geology, minors in Mathematics and Physics. Married, 35 years of age, good health, 3 children—two of school age. Would consider foreign assignment. Personal and professional references on request. Presently employed. Box 88-W, WORLD OIL, Houston, Texas.

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• MECHANICAL ENGINEERS—B.S., M.S., Ph.D.
Design and development of mechanical or hydraulic equipment and techniques for drilling and completion of wells; fracturing of earth formations; flow and treatment of well and pipeline fluids.

• PETROLEUM ENGINEERS—M.S., Ph.D.
Development of techniques and equipment for drilling and completion of wells; improvement of productivity into boreholes; production methods; fracturing of formations; consolidation of sands; development of thermal recovery techniques, reservoir behavior analysis, uses of pressure and temperature transients.

• CHEMICAL ENGINEERING—B.S., M.S., Ph.D.
Development of physical properties, chemical formulations, techniques of treatment and design of experimental equipment for investigation of colloidal fluids used in well drilling; chemical treatment of produced fluids; and other applications of chemical engineering to oil field production problems. Investigation of the chemistry and engineering of in situ combustion techniques for oil recovery; investigation of the pressure-volume-temperature relationships of hydrocarbons and the use of thermodynamical data in the production techniques.

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New Well Service Company Formed for Eastern Venezuela

Well Service Engineers, C. A., a new company to provide highly mobile well servicing in eastern Venezuela, has been formed by W. T. Carpenter of Dallas, and Z. M. Barnett of Shreveport. New equipment, shipped from Beaumont, Texas, in February, features many innovations in design to cope with the marshy terrain of the area and reduce moving and rigging up expense.

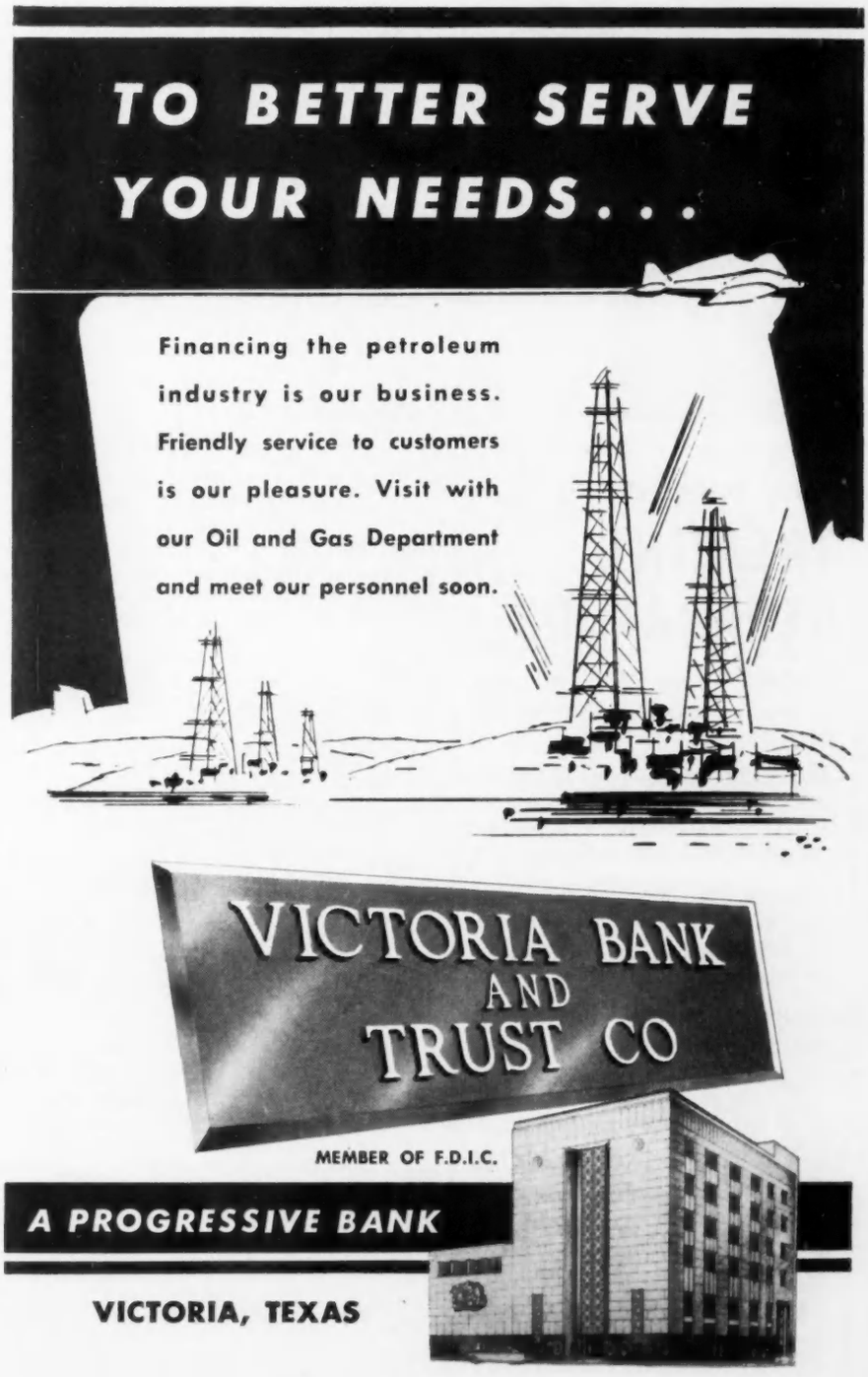
Carpenter and Barnett, both petroleum engineers, have had years of service with Venezuelan Atlantic Oil Company in the Oritupano district.

Working with equipment engineers of Ideco, one of the Dresser Industries, they devised a packaged rig-on-wheels entirely self-contained down to the trailer-mounted aluminum doghouse with sleeping quarters for four geologists, company engineers and other specialists. The fast-moving rig is designed to service any well in eastern Venezuela to a nominal depth of 10,000 feet.

Headquarters for the new company is at Santa Barbara in the state of Managas, Venezuela.

National Lead Company Acquires Mud Products Stock

National Lead Company is acquiring capital stock of Mud Products, Inc. of Tulsa by an exchange of shares. Mud Products will continue under its present name in its regular business of distributing products of the Baroid Division of National Lead. Ben R. Bourland, as new head of the distributing company, is the only personnel change planned.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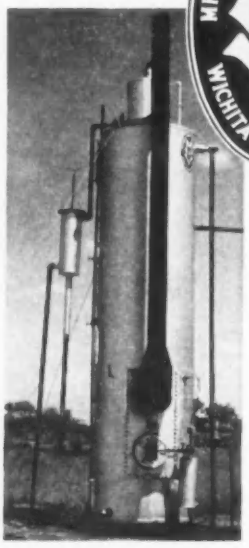

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SQUEAKS from the BULLWHEEL

Daily Double

A sweet old lady, always eager to help the needy, spied a particularly sad looking old man standing on a street corner. She walked up to him and pressed a dollar bill into his hand saying: "Chin up."

The next day, on the same corner, the sad old man shuffled over to the old lady and pressed a $10 bill into her hand. "Nice pickin'," he said in a low voice. "Paid nine to one!"

Thought It Was a Peanut

It seems that a touring Californian stopped at one of the many Florida roadside markets and upon seeing a watermelon, he asked, "What's the price of this cantaloupe?"

The clerk looked at the man, then at his license plate, and witheringly replied: "Take your finger off that olive."

Likely Reason

Steno: "The boss is making me do a lot of filing every day now."

Friend: "Why is that?"

Steno: "I scratched him the last time he tried to kiss me."

Oh, Like That?

"Is this candy pure?" the customer asked.

"As pure as the girl of your dreams."

"Gimme a pack of gum."

Fill Her Up

An engineer met a sweet young thing on the street, took her to a bar, and said: "What will you have, beer or champagne?"

She replied, "I believe I would like champagne cause when I drink champagne my head gets all bubbly and I have the most wonderful thoughts. I imagine I'm lying in the warm, languorous sunshine on a soft white dune of sand near the pale blue sea. I see a tall handsome man approaching me. He comes nearer and kneels at my feet and then gazes into my eyes. He leaves me, walks into the sea, only to reappear with huge shells filled with beautiful iridescent pearls which he pours over me.

"On the other hand, when I drink beer I just belch."

Good Reception

"Mamma, the garage man has a lot better radio than we do," the little boy said.

"How do you know, dear," his Mother asked.

"He said that when he goes home tonight he will get hell."

11 Jurors and 1 Jackass

The jury had been on the case all morning and was still undecided. The vote stood 11 to 1 for acquittal but one old codger stubbornly held out for a verdict of guilty. The sheriff came in at dinner time and asked what they would like to eat.

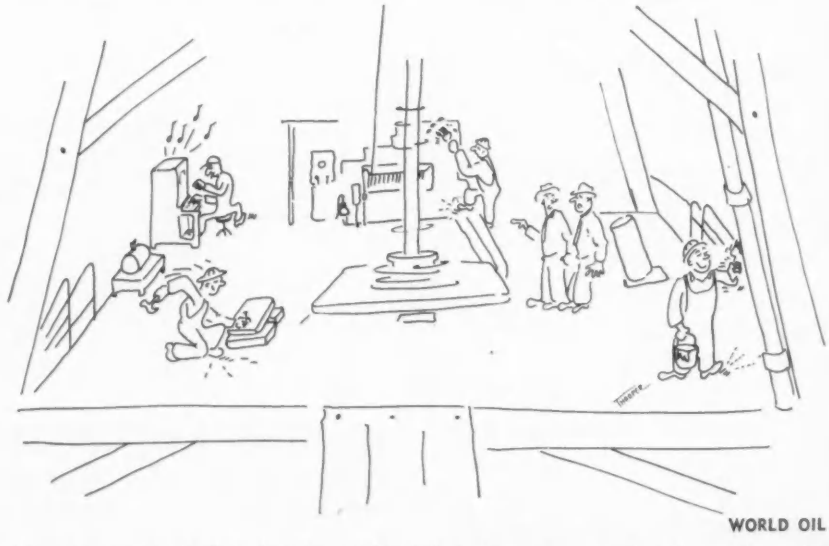
"Well," drawled the foreman disgustedly. "Bring us 11 dinners," and then added, "And a bale of hay."

Wrong Kind of Sympathy

A newly-made widow called at an insurance company office for money due on her late husband's policy.

Said manager, "I'm very sorry madam, to hear of your loss."

"That's just like you men," she snapped. "Always sorry when a poor woman gets a chance to make a little money."



"You may not like it, boss, but since I hired that piano player as derrickman, I've really got the work done."

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McCullough Log Enables Precision Perforating of 5′ Pay Zone

Discovers 8′ Error in Electric Log and Casing Measurements

Operator of this old well ran an electric log which located a new, possibly productive, 5′ sand.

McCullough was then called to run a Neutron Log. The Neutron curve confirmed the productive possibilities of the new zone, but also discovered that both the electric log and casing measurements were 8′ in error.

The well was plugged back to 6800′ and perforated according to McCullough measurements.

Thirty ½″ improved Ogival Bullets were shot in the 5′ sand in one run by a 3½″ O.D. McCullough M-3 Gun. Casing was 5½″ O.D. 17 lb.

The well started flowing through the casing before the M-3 Gun was out of the hole.

If the McCullough Radiation Well Logger had not discovered the 8′ measurement error, the 30 shots would have missed the pay zone entirely.

It always pays to rely on the accuracy and dependability of McCullough's Radiation Well Logger.

McCullough Log Locates and Defines 11 New Pay Zones

Accuracy of McCullough Radiation Well Logger Permits Sharp Shooting of 11 Thin Zones for 138 B/D Increased Production

This was an old well in an established California oil field. Production had fallen to five barrels of oil per day.

Believing better production was possible, the operator decided to log and re-perforate the well. McCullough's combination Gamma Ray-Neutron Log was run from 4380′ to 5645′, locating several small, promising stringers of untried sands above the original pay zones.

A simultaneous collar log accurately located casing collars in relation to these thin sands, thus assuring "pin-point" accuracy in perforating.

The two original producing sands were re-shot, four holes per foot, with 26 improved ½″ Ogival Bullets from McCullough M-3 Guns and with 26 McCullough Standard Casing Glass Jets.

Above these zones were the 11 small sand stringers ranging in thickness from 4 feet to 13 feet. Intermediate zones, lying between the productive sands, which were not to be perforated ranged in thickness from 5 feet to 103 feet.

Accurate measurement means "putting the shots where they count"... and the "pin-point" accuracy of the McCullough Radiation Well Logger makes sharp shooting of thin zones practical... assures uniform perforating coverage of any zone, thick or thin.

The 11 pay sands were perforated with 256 shots, four holes per foot, by 3½″ O.D. McCullough M-3 Perforators firing ½″ Ogival Bullets. Production increased from 5 to 143 barrels of oil per day.

This is only one of many actual jobs where the accurate, reliable, easily interpreted information provided by the McCullough Radiation Well Logger has located and defined multiple pay zones, tied-in casing collar locations and permitted precision perforating for best possible production.

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GOING FISHING? CALL YOUR FRIEND!
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"Man, that's what I call a structure!"

Substitute Wife or Vicar?

The dear vicar's wife had just died and he wished to be relieved of his duties for the weekend, so he sent this message to his bishop:

"I regret to inform you that my wife has just died and I would be obliged if you would send me a substitute for the weekend."

Short Memory

"There I was, forced down on a desert island with five lovely blondes."

"Gee, what did you do for food?"

"Darned if I remember."

Credit

A man mortgaged his home to buy an automobile. Then he went out and tried to mortgage the car to get money to build a garage.

"How are you going to buy gas?" asked the man from whom he was trying to borrow money.

"Well, if I own a house, a car and a garage, I should think any dealer would be willing to trust me for gas."

There's A Reason

Child: "I'll bet my daddy has more money than your daddy."

Other Child: "I'll bet he would't have if he was married to my mamma."

Can Read

Sailor: "I can't marry you. We have nothing in common. You don't even know the difference between port and starboard."

Blonde: "Couldn't I look at the label on the bottle?"

House Holder

Upon reaching home in the wee hours of morning, a gentlemen who had overindulged was having difficulty unlocking his front door. Just then the milkman came along and offered help, saying, "May I hold the key?"

"Naw," replied the confused fellow. "I can hold the key—you hold the house."

Hazards of Age

The rich old gentleman was sitting in his wheelchair beside an open window as a slick chic walked by, displaying a comely figure.

"Quick Jenkins," called the old gentleman to his valet. "Bring me my teeth. I want to whistle."

Concern

"How are you this morning?"

"All right."

"Well, you ought to notify your face."

Strategist

Mother to small boy: "If you say one thing more to me I'll make you eat your words."

Small boy: "Chicken & dumplings, hot biscuits and ice cream."

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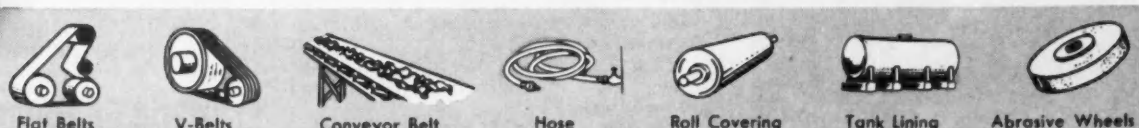

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"And this one I bagged on that last well location over in the Bayou Country!"

Just in Case

A problem child was becoming too well-acquainted with the principal's office. One day the principal showed her annoyance. "This makes the fifth time I have punished you this week. What have you to say for yourself?"

"I'm glad it's Friday."

Is That So?

Policeman (to intoxicated man trying to fit key into a lamp post): "I'm afraid there's nobody home there tonight."

"Mus' be. Mus' be. Thersh a light upstairsh."

Fashion Notes

A WORLD OIL secretary complains that the new look doesn't get the old look from her boy friend.

Who Wants to Be Strong?

It's a great life provided you weaken in time to enjoy it.

Better Than That

"You mean to tell me that in Texas you have 365 days of sunshine a year?"

"Exactly so, suh, that's a mighty conservative estimate, too."

Same Thing

"I'm not going out with Bill anymore. He knows too many naughty songs."

"Does he sing them to you?"

"Well, no, but he whistles them."

Good Grounds

Judge: "What do you wish to charge against your husband?"

Wife: "Free love, Your Honor, He ain't supported me for six years."

Blonde Success

The blonde who can keep her hair light and her past dark is always happy.

What Dosage?

The young bride approached the druggist timidly.

"That baby tonic you advertise," she began. "Does it really build bigger and stronger babies?"

"We sell a lot of it," the druggist replied. "And we have had no complaints."

"Then I'll take a bottle," she said. "But do I have to take it, or does my husband?"

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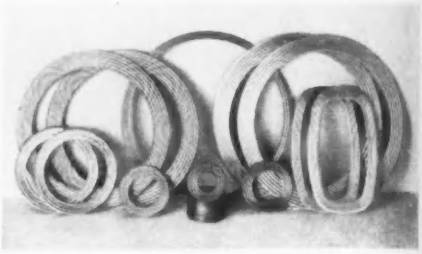

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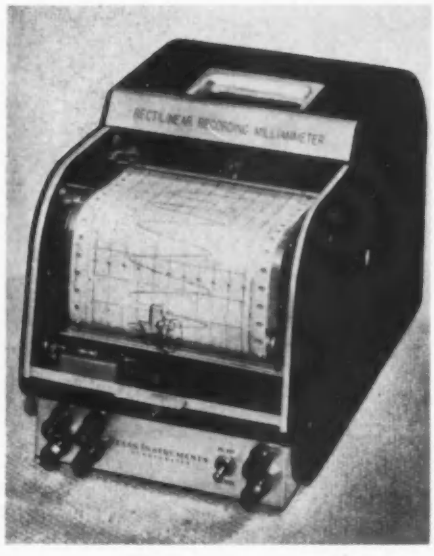
What's New In Equipment

Drilling • Production • Exploration



Rectilinear Milliammeter

The first rectilinear recording milliammeter has been announced by Texas Instruments Incorporated. It is a ruggedized, ink-writing, galvanometer-actuated instrument, with front access for all routine operations.

New convenience features include: Front-located signal terminals (rear terminals optional), front-located switches and controls, writing desk area on chart for notations, disappearing sliding door, front-located zero adjust, convenient front-filling inking system, enclosed to prevent spilling, swinging chart paper carriage for easy paper reloading, and accessibility to perform all routine maintenance and adjustment procedures without removing case or disassembly, and finger-tip gear-shift for changing chart speeds.

Rectilinear writing is made possible by a pantographic linkage. This includes a durable, fixed, jeweled gymbal mounting for the non-corroding pen and a freely moving A-frame with counter-balancing weights that insure uniform pen pressure throughout the full 4½ inch deflection and simplify calibration and adjustment.

The new rectilinear recording milliammeter weighs less than 27 pounds and occupies less than ¾ cubic feet, measuring 15 inches by 9 inches by 8¼ inches.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.

Scintillation Counter

A new scintillation counter with a built-in loud speaker alarm has been placed on the market by Gardiner Electronics Company. The loudspeaker gives out a tone when a preset gamma radiation level is reached and increases in pitch proportionally as this level is exceeded.

With provisions for headphones for use while flying or using in a noisy place, the new unit also features a built-in battery tester that individually tests each battery in a few seconds.

It has an eight-range switch covering ranges .01, .025, .05, .1, .25, .5, 1, and 5 MR/HR and time constants of .2, .5, 1, 5 and 25 seconds. It uses a thallium activated sodium iodide crystal size 1½ inches by 1-inch.

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Mobile Drill

Newest unit announced by Mobile Drilling, Inc. is a hydraulically powered drill, the Model B-40. Engineered to operate as a core or auger drill, the B-40 may be adapted for tractors and vehicles or independently driven by a motor mounted at the rear of any vehicle. For hard formations, either air or water may be used with hollow-stem augers.

The drill cores to 200 feet and augers to 75 feet. A 15-horsepower hydraulic motor is geared to high torque low speeds and assures a positive, steady drill action.

One-man operated, the drill can be converted easily to drill at any degree in a 360-degree angle, and is light enough for air transport to remote areas. The drill has the proper rpm to give the high torque necessary for auger drilling and by using five-foot sectional augers of various dimensions, holes may be drilled quickly with resulting speed-up in exploration of formations.

For more data, circle **No. E3** on Readers' Service Card, last page this issue.

Portable Radiophones

A new line of transistorized portable two-way radiophones, delivering up to 20 times the RF power output conventionally attained in such equipment, has been announced by Motorola's Communications and Electronics division. Chiefly responsible for power output capability and trebled receiver audio output are several recent advances in the development of transistors, plated circuitry and lightweight, long-life power packs.

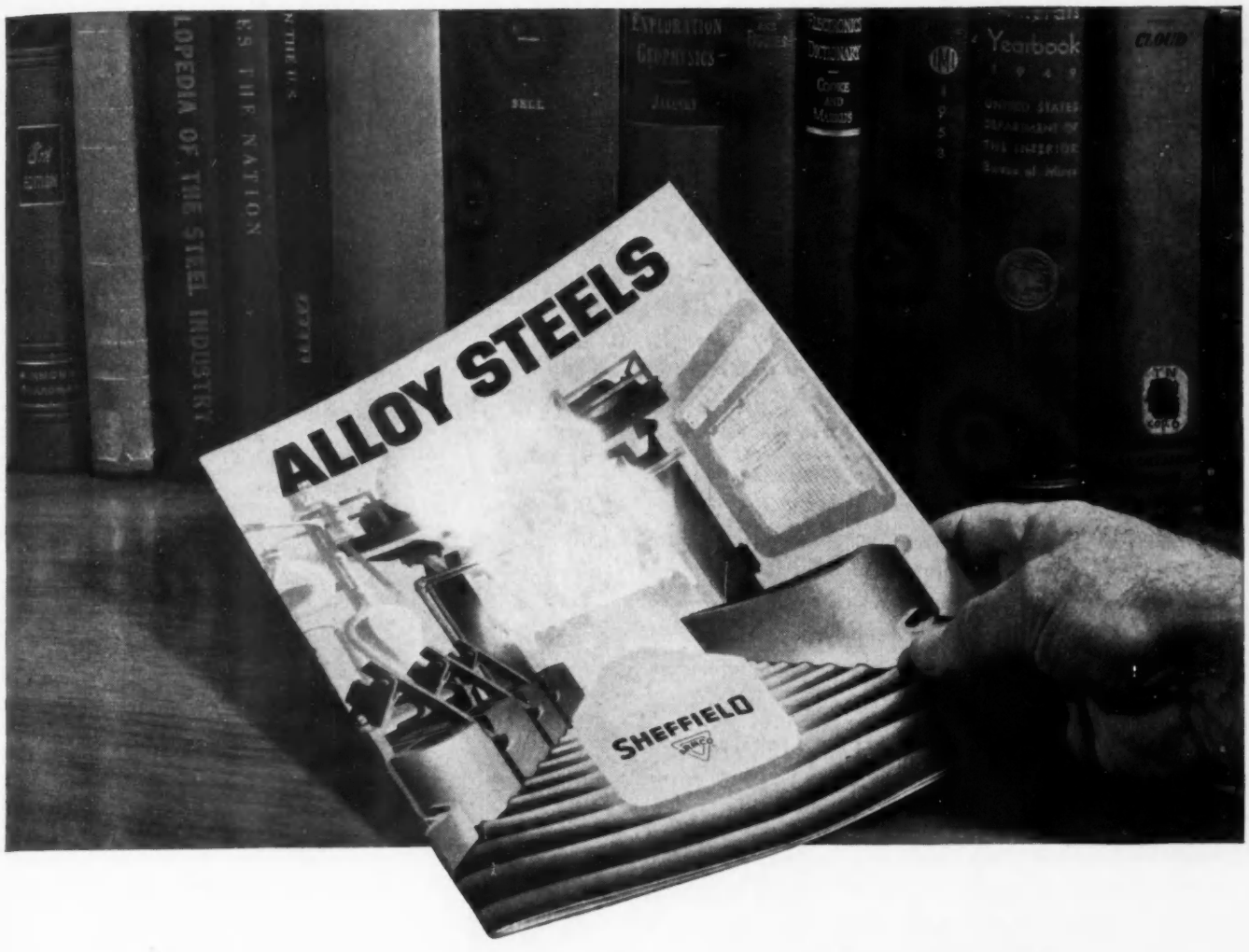
The complete line includes models with RF power output ratings from 1 to 8 watts. Coincident with the increased power output is a decrease in weight and size of as much as 50 percent. All units are housed in sturdy, formed aluminum cases. Lightest and smallest model weighs only 7 pounds, 9 ounces complete. A full 8 watts transmitter power output is available from a model weighing only 15½ pounds. Extensive utilization of transistors, including use in transistorized power packs, also extends battery life for minimum operating costs.

Another feature of the equipment is the snap-on power pack. Dry cell, wet cell and 117 VAC power packs are interchangeable. Wet cell power pack employs lifetime, rechargeable nickel-cadmium cells and includes option of operation from 6 and 12 volt vehicular type batteries.

The line includes models in the 25-54 mc. and 144-174 mc. frequency range in both handset type microphone and speaker-palm type microphone versions.

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Save time! Keep informed! Circle numbers on Readers' Service Cards, last page this issue



Reach for this Book When You Have A Question On Quality

The quality of alloy steels is important to you . . . whether you're a manufacturer who wants to build more quality into your products, or a consumer who wants to get more quality for your money.

The book you see above is a comprehensive manual of information on alloy steels. It tells, among many other things, why you can be sure of the quality of Sheffield Alloy Steels. Tells how they're "babied" every step of the way from furnace to finished steel; how the most advanced chemical, electronic and mechanical tests and controls keep Sheffield quality at prescribed high levels.

There can be no compromise with quality in steel for such products as drill bits and aircraft (to name just two of many end-uses of Sheffield Alloy Steels). Get this same standard of consistently high quality in Sheffield Alloy Steels tailored to your specific product demands. Contact our Houston office for engineering counsel and cooperation.

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cut costs...speed exploration with

PORTADRILL model BHD-C

REG. U.S. PAT. OFF.

designed and engineered for lower cost, faster completion of

SEISMIC "Shot Holes"

GEOPHYSICAL OPERATIONS

CORE DRILLING

MINERAL SAMPLING

and other vertical hole work

with either AIR or WATER

The Portadrill BHD-C is an integral unit drill which includes *both* a highly efficient air compressor and a 5x6 mud pump. It is particularly adapted to all types of exploratory work since the fastest method of penetration may be used, depending on the type of drilling to be done and the formations or drilling conditions encountered.

NO AUXILIARY EQUIPMENT NEEDED

The BHD-C is completely unitized. No auxiliary equipment is necessary. The Portadrill Design permits complete servicing or parts replacement in the field. The prime mover furnishes all drilling power through a series of power take-offs transmitting full torque to the drilling components. Two men operate the BHD-C with complete efficiency.

The maneuverability, the versatility, the dependability of the BHD-C will cut costs, speed your exploratory work. Complete details and specifications are included in Catalog "C."XXX The maneuverability, the versatility, the dependability of the BHD-C will cut costs, speed your exploratory work. Complete details and specifications are included in Catalog "C." Ask for it today!

Portadrill units include conventional; combination air-water; "air blast," Reverse Circulation and tractor mounted drills, all in rotary types.

PORTADRILL

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MANUFACTURED BY

The WINTER-WEISS Co.

2201 BLAKE ST., DENVER 5, COLO. USA

Magnetometer

The Radiac Company, Inc., announces production of the Sharpe Model A-2 vertical force magnetometer, a Schmidt-type magnetic balance for precise measurement of the vertical magnetic field intensity of the earth. The A-2 can be used to trace favorable ore formations in drift-covered areas. It also serves as a direct guide to favorable ore locations in the absence of rock outcroppings. Since profiles of readings may be taken at selected sites, such as between widespread outcrops or on the extension of a known geological condition, a formation may be preliminary traced without performing an extensive survey.

The magnetometer has a permanently attached compass for orientation to permit complete one-man operation. It has a sensitivity of 15 gammas per scale division and an intensity range of 0 to 15,000 gammas, which may be increased by the use of greater strength auxiliary magnets.

For more data, circle **No. E5** on Readers' Service Card, last page this issue.

Flow Control Device

The Hydro-Lok Flow Control, designed by Ralph A. Kerr, has no shock or waterhammer, no packing gland, no valve seats, no valve plungers, no wedges, no valve pistons, no flow interruptions, and no flowing liquids to cut metal moving parts, discs, plugs, seats, wedges or gates. Replacement of the sleeves or liners can be done simply, requiring no special tools or trained mechanics. All replacements and repairs can be done in the field.

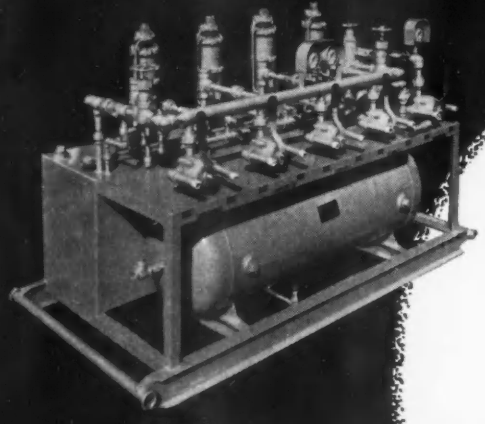
In drilling a well, it eliminates moving parts before submitted to abrasion on mud pumps, and it controls sensitivity of flow at all times.

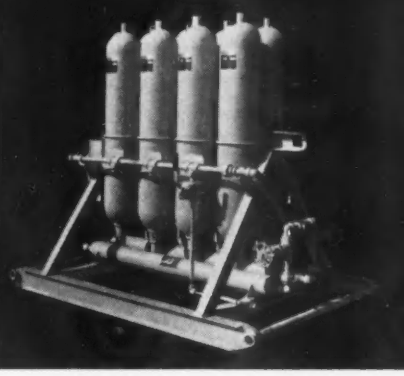
Toolpushers can use the device as a blowout preventive or master control in the hole, with a compressed air or liquid trigger device that would instantly close the hole regardless of what tools were within. With the device, flow control on allowable production of each well could be determined gallon-wise through visual flow. Offshore production can enjoy maximum safety in the control of marine production in that Hydro-Lok lends itself to automatic and remote controls.

American Flow Control is owner of exclusive manufacturing and merchandising rights under the patent applied for by Kerr covering the new-type device.

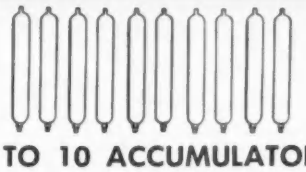
For more data, circle **No. E6** on Readers' Service Card, last page this issue.

Get Maximum Blowout Protection for your rig with-



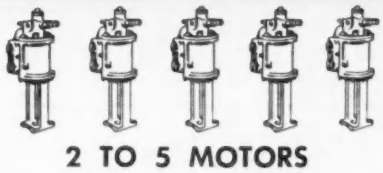


KOOMEY
Blowout Preventer
CLOSING UNITS
and
S.& S. "Power Packaged"
ACCUMULATORS



3 TO 10 ACCUMULATORS

Individual ten-gallon accumulator bottles (3000 psi working pressure) in manifold to form a compact system that will operate even if several of the nitrogen filled bags within the bottles should fail.

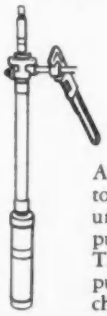


2 TO 5 MOTORS

Heavy duty units which require no oiling or maintenance . . . completely separated from pumps for ease of repair and to eliminate danger of material being pumped seeping into motor.

2 TO 5 PUMPS

Each double action pump assembly is operated by a separate motor and each motor and pump assembly is capable of closing the rams of a blowout preventer independently.



QUICK PUMP CHANGE

All a roughneck need to do to change pumps is break one union, substitute an exchange pump and tighten the union. Thoroughly tested, guaranteed pumps are available for exchange.

REMOTE CONTROLS

Added safety is provided by dual controls — one set on the rig floor and the other at a safe distance from the rig.

COMPLETE INFORMATION AVAILABLE

Detailed information on all models plus service instructions, parts descriptions and performance specifications and an easy-to-use model selection guide are contained in a new 44-page catalog. Write today for your copy.

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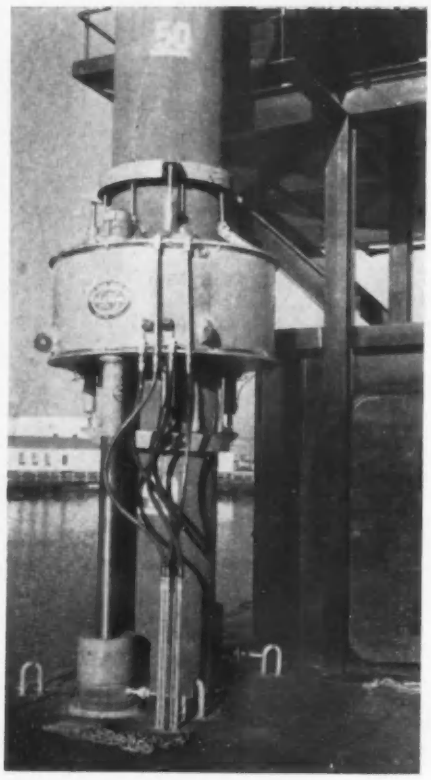

Spud Jacking Device

A custom-designed lifting mechanism to raise offshore drilling barges on spuds has been devised by Joe Stine Inc. The unit, called a hydraulic spud-jack, is used on offshore barges in various multiples, based on weight lift and other factors required of equipment. Each unit has separate controls and central pump system for actuating the hydraulic mechanism.

The unit shown locked on spud has an approximate 30-inch OD. It is comprised of hydraulically operated piston, cylindrical housing that locks around spud, conventional slips, pump and controls, with various fluid hose lines. When slips are set, the unit has a four-foot piston stroke.

Operation of these units, in unison, can raise equipment quickly and efficiently to any spud height required.

(This item supplements Joe Stine Inc. data on Pages 4776-4779 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

Welded Steel Tanks

Delta Tank Manufacturing Company, Inc., now is producing 90 to 400-barrel capacity welded steel tanks for oil field use. Welded construction facilitates their movement from lease to lease by eliminating knock-down and re-set problems encountered with bolted tanks.

Made from ¼-inch steel plate, the tanks meet API-12C code requirements and are designed for assembly in batteries. Standard fittings of the new line of tanks include 24 by 36-inch cleanout openings, anti-channel drain lugs, 3-inch combination pressure vacuum relief and thief hatches and walkway lugs. The tanks are shop-tested and painted with coats of shop primer and aluminum.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

Aerator Tower

An aerator for waterflood and water disposal operations is the latest product development of National Tank Company. The prefabricated redwood tower utilizes plastic trays instead of conventional wooden trays to reduce scale accumulation with resultant reduction in frequency of cleaning. Trays are reached through bolted side panels. Aerator units are produced in a wide range of capacities and sizes.

(This item supplements National Tank Company data on Pages 3621-3640 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

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AMERICAN IRON
Slush Pump
VALVES
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out-last and
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Check these outstanding features!
● Three-web seat provides maximum fluid passage with adequate strength for high pressure operation.
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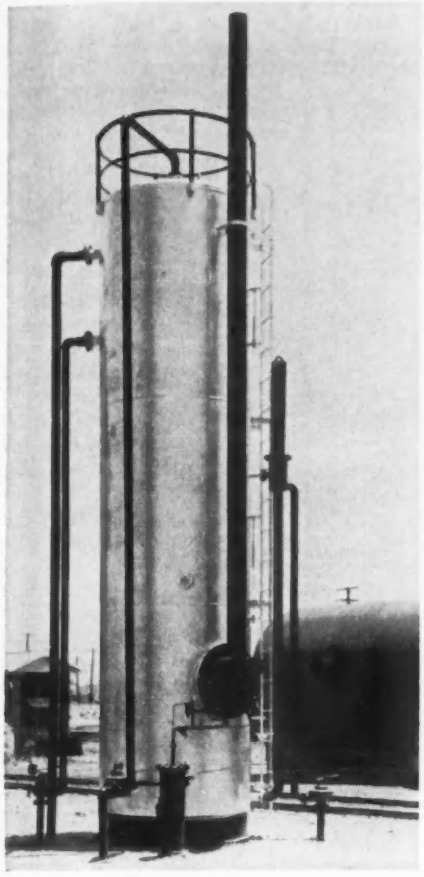
OILFIELD EQUIPMENT
OKLAHOMA CITY U.S.A.
PESA



Pressure Treater

Delta Tank Manufacturing Company, Inc., has developed a new line of 24-foot-high vertical pressure treaters with daily emulsion capacities ranging from 150 to 3500 barrels. The new units obtain maximum separation by limiting emulsion agitation.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

Spark Plug

A new type oil field spark plug which was still operating satisfactorily after 32 months of continuous operation recently was reported by Bethlehem Supply Company. Known as the New Triple Ignitor, which is manufactured by the Stitt Ignition Company, the plugs were installed in April, 1953, by Bethlehem Supply in an NK Waukesha gas engine powering an Ingersoll-Rand compressor for the Richfield Oil Corporation. When this unit was placed on a stand-by basis, the plugs were removed and inspected. Because of their small gap opening, in spite of two years and eight months continuous operation, additional service could have been obtained if desired. The magneto suffered no breakdown or mechanical difficulty because of the small amount of gap opening.

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

LOOK TO

Strata-Crete 6*

® TRADE MARK

improved perlite aggregate for **better** *bridging action in oilwell cementing*

Here's the Proof:

In laboratory tests made by an independent consultant, it was found that neat cement, with or without gel, flowed through both a 0.125″ and 0.172″ diameter hole at only 25 psi differential or less. These same holes were bridged successfully with **Strata-Crete 6** mixes of 1/3, 1/2, or 1 cubic foot per sack of Portland cement. The **Strata-Crete 6** bridges withstood not *less* than 1600 psi differential with a minimum loss of slurry.

This is one of the important reasons why actual cost to fill an annulus with a **Strata-Crete 6** slurry is usually less than the cost when using other cement mixtures. The increased bridging strength exhibited by **Strata-Crete 6** slurries has been brought about by an improved gradation of particle sizes. The improved bridging properties plus lightweight results in less loss of slurry to formations.

Strata-Crete 6 is available from leading oilwell cementing service companies.

In Canada, **Strata-Crete 6** is produced by Western Perlite Co., Ltd., Calgary, Alberta, and is sold by Import Tool Co., Ltd., Calgary, Alberta.

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GREAT LAKES CARBON CORPORATION—PERLITE DIVISION

P. O. Box 2050

Houston 1, Texas

*Refers to gallons of water for each cubic foot of **Strata-Crete 6.**

NEW EQUIPMENT . . .

Down Hole Separator

The Guiberson Corporation's down hole separator eliminates the problem of gas locks, etc. in pumping wells where produced fluid has a high gas/oil ratio.

Less than a foot long, the separator is screwed directly into a Guiberson packer and the pump shoe fitted directly onto the separator. One to four joints of by-pass pipe, depending upon producing characteristics of the well, are screwed into the separator and clamped to the tubing. Attached to the top of the by-pass pipe is a half-coupling cut on a diagonal which guides the unit past casing joints. By-pass pipe hugs the tubing as snugly as coupplings permit.

Production crosses over from the tubing below the packer into the annulus above it and is carried well above the pump shoe by the by-pass pipe. The large annulus above the packer allows the gas to break out of solution and oil drops back to the large reservoir above the packer where it is picked up by the pump, comparatively free of gas. The separated gas is bled off of the casing continuously.

Intake ports on the separator have a larger by-pass area than the tubing. The separator is precision machined from cast steel.

(This item supplements The Guiberson Corporation data on Pages 2081-2088 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E12** on Readers' Service Card, last page this issue.

Gas Turbines

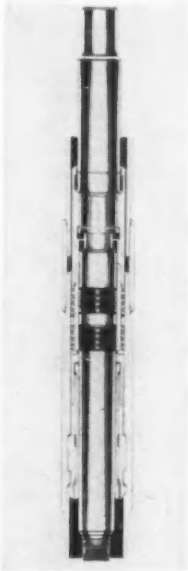
Three hundred million cubic feet of gas will be pumped back into the earth daily by the most powerful concentration of gas turbines in the world. Built by the Westinghouse Electric Corporation, twelve 8000-horsepower combustion gas turbines with a total maximum rating of 96,000-hp will be installed seven miles out on Lake Maracaibo, Venezuela, on a platform 440-feet long, 131-feet wide, mounted on concrete piling in 80-feet of water. They will drive centrifugal compressors which will inject natural gas, derived from oil operations, under high pressure into the oil field that is under Lake Maracaibo and the surrounding area. This gas conservation plant will recover substantial quantities of additional petroleum and conserve large quantities of gas, in fact, 120 percent more than its earlier counterpart in the same area.

Eight of the units will be direct connected to the centrifugal compressor, four will be geared. The twelve turbines will operate in two strings of six units each.

For more data, circle **No. E13** on Readers' Service Card, last page this issue.

Landing Nipple Casing Packer

Otis Pressure Control, Inc., has placed a new landing nipple casing packer on the market which seats in a landing nipple made up in the casing string. Called the Selective collet-type casing packer, it is a retrievable tubing-to-casing pack-off tool which can be run, set and pulled on the tubing string or sand line.



Assembly consists of the casing landing nipple, a packer body, a seal nipple assembly and a locator assembly for the packer body. Tubing weight is not necessary to set the packer, nor is rotation necessary to seat or unseat the tool.

Heavy-duty collets lock the packer securely in position and no slips are used which might damage casing wall or become corroded. The packer is capable of withstanding extremely high pressures both from above or below.

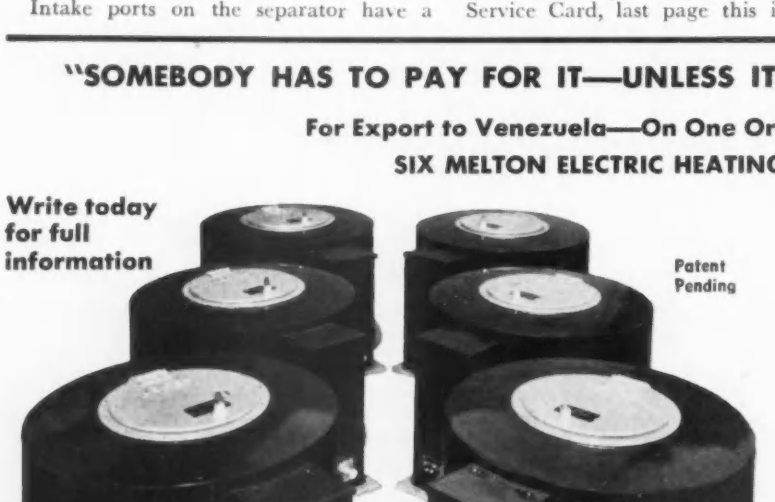
(This item supplements Otis Pressure Control, Inc. data on Pages 3985-4020 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

"SOMEBODY HAS TO PAY FOR IT—UNLESS IT SHOWS UP IN THE SHAKEOUT."

For Export to Venezuela—On One Order for One Company
SIX MELTON ELECTRIC HEATING CENTRIFUGES

Write today for full information



Patent Pending

Are you getting true tests of your oil? Are your samples being shaken out at the proper speed and is it at the proper temperature at the end of the shakeout?

Don't pay for or handle oil you don't get, and don't pay taxes on impurities, or let them take up part of your allowable.

Test your good or bad oil the usual way, and then test it with the Melton Heating Centrifuges. You will be convinced.

Melton Electric Heating Centrifuges can be furnished in:

Model A-2-6 for 6 volt batteries
Model A-4-6 for 6 volt batteries
Model B-2-6 for 6 volt batteries
Model A-2-12 for 12 volt batteries
Model A-4-12 for 12 volt batteries
Model B-2-12 for 12 volt batteries
Model A-2-6-S for 6 volt batteries
Model A-4-6-S for 6 volt batteries
Model A-2-12-S for 12 volt batteries
Model A-4-12-S for 12 volt batteries
Model B-2-6-S for 6 volt batteries
Model B-2-12-S for 12 volt batteries
Model C-2-12 for 12 volt batteries
Model A-4-115 for 115 volt A.C.
Model B-4-115 for 115 volt A.C.

Fully guaranteed against any failure of any part of the entire unit for one year from date of purchase.

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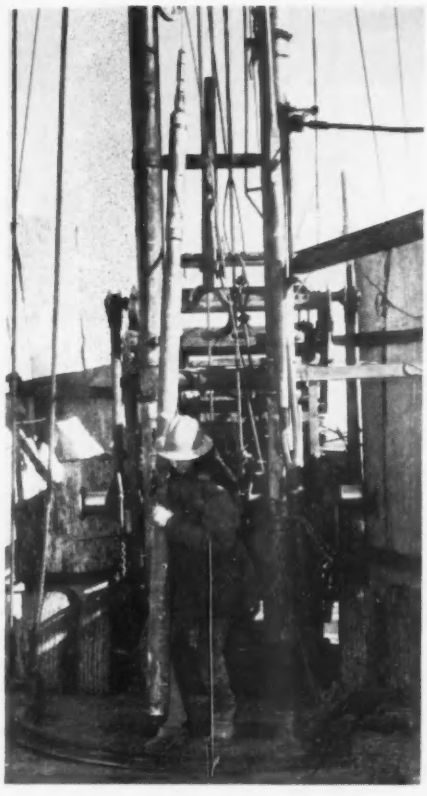
DRILLING



Combination Logging Tool

A combination logging tool which permits (1) finding depths of pay zones accurately in oil and gas wells by use of a gamma-ray probe and (2) perforating the well casing before removing the probe from the well is announced by BIRD WELL Surveys.

Features of the new "Gamma ray-Perforator" are precision and increased speed for opening up pay zones economically. These advantages are assured by elimination of the customary, separate gamma ray and perforating runs. The method also eliminates collar counting as a means of finding pay zone for the gun perforator.

Detector design provides for easy field maintenance and reliability in spite of the tremendous impact that occurs when the perforating tool is fired. This is accomplished with the same quality of gamma-ray logs as produced by the conventional method.

Two sizes of gamma-ray detectors are being used with four sizes of perforating guns ranging from 3⅛ to 5 inches in diameter. Perforating guns incorporate the latest-type jets for effective penetration and hole diameter.

As shown, the combination logging tool, after firing the perforator, is hoisted to the surface and removed by the operator.

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

Slim Hole Rig

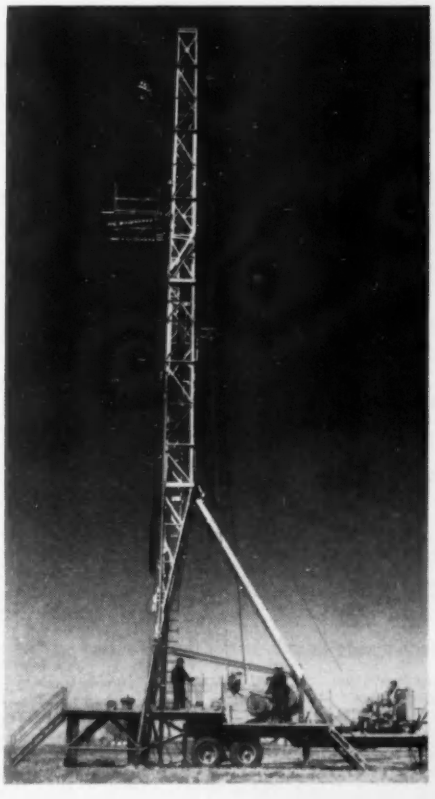
The George E. Failing Company, subsidiary of Westinghouse Air Brake Company, has announced production of a new slim hole drilling rig, the Stratmaster. Designed for production drilling and stratigraphic exploration, the Failing Stratmaster will go to depths of 6500 feet with 2⅞ inch drillpipe. It was designed as a legal highway package and can be moved on to location and rigged up within a few hours. The rig is eight feet wide and 50 feet long in traveling position. It is trailer mounted and weighs approximately 50,000 pounds.

The rig has a cantilever type mast with a horizontally retracting top section. The mast has 83 feet clear space for the drill string and has a hook load capacity of 100,000 pounds.

There are no guy wires on the mast or platform and five-foot clearance is provided under the rotary table without trailer ramps. Power for the unit is transmitted from an engine mounted on the drill frame through universal joint equipped torque tube drive. Transmission is an Allison torqmatic with three speeds forward and one reverse and may be shifted under load.

All controls in the Stratmaster are air operated and grouped in a console at the driller's position forward of the draw-works. The rig is designed for use of Range Two drillpipe and drill tubing. The rotary table has a 16 inch opening. Either gas or diesel engines may be used.

(This item supplements George E. Failing Company, subsidiary of Westinghouse Air Brake Company, data on Pages 1637-1660 of the Composite Catalog, 21st Edition.)



For more data, circle **No. E16** on Readers' Service Card, last page this issue.

PERFORATE TUBING IN THE WELL

KINLEY TUBING PERFORATOR

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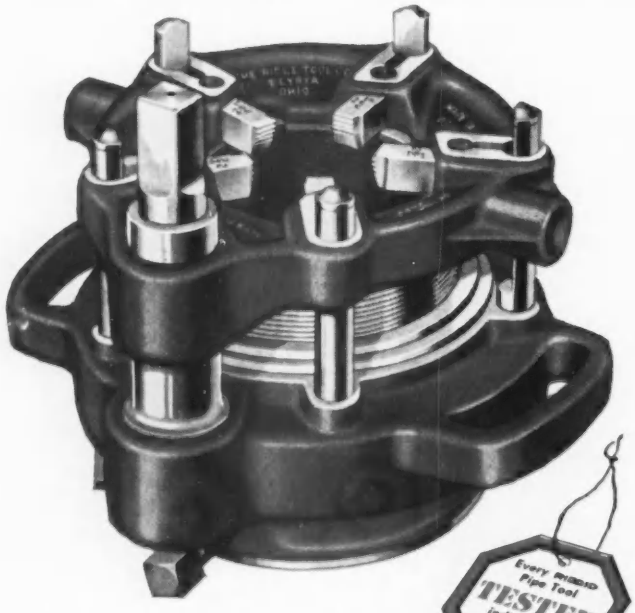
Circle numbers on Readers' Service Cards on last page

Easy Does It

...it's always easy with this geared pipe threader with big easy-grip handles

RIDGID

No. 4P Die Stock for 2½" to 4" Pipe



Easiest 2½" to 4" geared threader to work with. Set mistake-proof workholder to size *before* you put it on pipe—one screw to tighten, no bushings. Big balanced handles—easy to swing up on pipe. 4 sets of 5 dies; ratchet handle—RIDGID Drive Shaft and Power Drive make for easiest possible threading. 4P for conduit available. Order from your Supply House.

"Threaded Pipe—*It's Tight—It's Best—Costs Less*"

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FOR SWABBING

AUTO-RELEASE WIRE LINE STRIPPER

Finest in the field. King Strippers represent outstanding advances in design and construction that assure long life and maximum operating efficiency:

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- SURE RELEASE MECHANISM operated by rope socket striking bottom of the stripper.
- NON-SPARKING MATERIALS minimize fire hazard.
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- SIDE OPENINGS for inserting packing while line is in the hole.
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To establish conclusive proof of the accuracy of our geophysical work, we will, without cost to you, test and record a log of your well on tape, bearing your signature and ours, of your rank wildcat location, in advance of drilling, indicating the existence or not of petroleum in commercial quantities underlying the tested areas and approximately at what depth it may be found. The instruments are entirely self-operating during testing period.

GEOPHYSICAL SURVEY SYNDICATE

4133 Sunnyslope,
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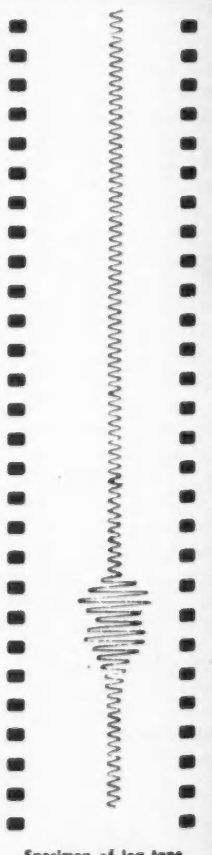

Specimen of log tape indicating saturation with break in zone